The Journal
OF THE
Royal United Service Institution.

VOL. XVI. 1872. No. LXVI.

Evening Meeting.

Monday, January 15, 1872.

VICE-ADMIRAL SIR FREDERICK W. E. NICOLSON, Bart., Vice-President, in the Chair.

NAMES of MEMBERS who joined the Institution between the 1st and 15th January, 1872.

LIFE.

Beaumont, Lewis A., Lieut. R.N.

ANNUAL.

Austen, A. G., Major-Gen. R.A.
Creak, Ettrick W., Lieut. R.N.
Dundas, James D., Major 60th Rifles.
Howard, F. C., Lieut. Rifle Brigade.
Hamilton, H. B., Capt. 6th Drag. Gds.
Miles, H. S. G., Lieut. 101st Regt.
Jackson, H. M., Lieut. R.A.
Pilgrim, Charles, Capt. Bucks Yeo. Cav.
Stopford, Hon. J. M., Lieut. Edin. or Queen's Reg. of Light Inf. Mil.
Vickers, C.B., Lieut.-Col. 48th Middlesex Rifle Volrs.
Battye, Wigram, Capt. Bengal Staff Corps.
Fynn, R. N., Esq., late Lieut. 2nd West York Mil.

The CHAIRMAN: As this is the first evening meeting of the year, the members of the Institution will be glad to learn from me that in the past year, 237 Members joined the Institution, being an increase of 59 over the number that joined us in the previous year. In an Institution like ours, a considerable accession of Members is always a good test of progress, and I am happy to say that that increase appears to be still going on. Gentlemen present, are probably aware that we are approaching what we may call a crisis in the fortunes of the Institution. We trust however that we shall come out of that crisis with an increased addition to our numbers, and with increased opportunities for lectures and discussions, such as we have had for some years in this theatre. With these preliminary remarks, I will now call upon Captain Colomb to read his paper on "The Attack and Defence of Fleets."

THE ATTACK AND DEFENCE OF FLEETS.

Part II.

By Captain P. H. Colomb, R.N.

Much of the neglect under which my subject undoubtedly lies, may proceed from an idea which impressed me very strongly at one time, namely, that the attack or defence of a modern fleet cannot be profitably studied prior to the experience of many actual combats. It seems at first sight probable that no such thing as rule or law can be evolved except from the facts of experiment in war. It is therefore readily assumed that naval strategy is not yet in a condition to be made a subject of study. This line of thought would be excusable after many failures to discover the hidden law or laws which may exist, but it does not excuse the neglect to seek for them. We have no business to make the assumption in the first place, for it is founded on no data; and, moreover, I trust to have shewn in former papers that so far from being the vague conglomerate of conflicting opinion generally supposed, a very superficial analysis recovers many points of absolute certainty round which theories may safely revolve, or, at the very least, gives encouragement to persevere.

There are, however, two ways of approaching the study. The first is very easy, very common, and very misleading. The second is slow, troublesome, rare, but may lead us to the very centre of the maze. The first is the empirical or ratiocinative method—the second, the inductive. The first assumes some theory of attack and defence, some pet formation, or favourite weapon, and argues to the particulars of a combat founded on these assumptions. The latter assumes nothing at the outset. It establishes particulars by observation and experiment, and then collates, or colligates, as it has been called, these particulars, until it weaves them into general harmony. The former method *may* turn out a truth in the same way as you may throw sixes with dice. The latter method may be less brilliant, but what it establishes is reliable, and in any case such errors as occur, are capable of detection before the general result comes to be applied in war, for they must be caused either by some mistaken particular, or by some wrong application of particulars which are in themselves true.

I need not say which of the two methods has my approval, or on which of them I intend to base my present enquiry. My former paper* sufficiently shewed that I was content to make any sacrifice rather than proceed to generalise hastily. But in applying such particulars as I assumed to be established when I last addressed you, I must ask you to bear in mind that they are assumptions still, in a greater or less degree. There is not one of the points then adverted to which will not bear—nay, which does not imperatively demand—rectification by observation and experiment. I deny absolutely that we can form any

* See Journal, vol. xv, page 405, *et seq.*—Ed.

correct notion of what a future naval action will be from the colligation of circumstances which we do not know absolutely to be facts. At the same time I hold in good faith to the theory that if we knew accurately all the facts which can be established by experiment and observation in peace time, we should have materials amply sufficient to guide us to complete success on the first occasion of putting our theory into practice against an enemy.

These remarks are not unnecessary at the outset of my paper. There is not one of us naval Officers who has not either heard or expressed the most decided opinions on the efficiency of certain formations and the inefficiency of others; yet I venture to say not 10 per cent. of us have ever heard any good reasons as to why one formation is better than another, and not 2 per cent. have ever thought out the matter even superficially for themselves. The danger we run of committing ourselves to some definite theory of attack and defence without any inductive steps leading up to it, is real and tangible; and if, instead of advocating a particular view, it should come to pass that I show the end farther off than ever, and leave your minds open on the questions, I shall not consider I have done bad service.

I must now advert to an opposite opinion on this matter which is held by men of greater practical experience than my own, and of deservedly greater weight. It is very strongly held by these that it is far more important to have a plan than to have a good plan of attack or defence. It is insisted that the Admiralty would be wise now, with our present information, in deciding on a particular formation and mode of attack, and in enforcing its use on our Admirals, so far as excluding all other plans from the Signal Book goes. The issue raised is very distinct, but it is not one I am called on to argue here. For, if I be wrong in supposing a bad compulsory plan to be worse than no plan, still, as no plan is yet adopted, such investigations as mine go to establish not only a plan, but, if properly conducted, a good plan, even though, as I before remarked, the attainment of one were so far off.

It is now incumbent on me to state what the aim of my arguments will be.

I understand the success of a fleet action will depend jointly or severally on four things, namely, material superiority, moral superiority, superior mobility, and superior position.

Material superiority we have nothing to do with. If we have it, and an equality in the other three things, we shall win without a discussion. Moral superiority is often confounded with strategy, and often spoken of as though it were a possession not only exclusively English, but incompatible with strategic skill or even strategic plans. I hope I should be the last to despise that fire, dash, and stolid determination which hurled a Nelson on the van of the French at the Nile, and on the head of the Mole at Santa Cruz. I trust no English naval Officer will ever forget that, guns or no guns, rams or no rams, torpedoes or no torpedoes, he who places himself most completely in the spirit of Nelson's orders to his Captains is doing the best service to the State, and runs most chance of winning. If nerve gained naval

victories for us a century ago, surely those who have it in superiority possess an increased power now! But the instances I quoted of Nelson at the Nile and Nelson at Santa Cruz are sufficient to indicate that bravery and strategy combined are very much more powerful than bravery alone. The brave man had better be intelligently brave while he is about it. It may raise his reputation for pluck to win with great loss, but it will benefit the State more that he should win with small loss. Besides, a man cannot be argued into bravery, and he can be taught strategy.

Again, mobility in a fleet must be attained before the latter can be strategically employed. I pre-suppose we have it in equality with the other side. Of the four qualities set out there remains now only the last—superiority of position. What constitutes it and how to gain it, is the subject I intend to discuss.

To those, therefore, and they are many, who pin their faith on the moral superiority given by audacity and nerve, and propose without any plan to rush upon an enemy's fleet and frighten him into submission, I have nothing to say of a controversial character. I am not about to argue whether audacity be a greater or a less powerful weapon than skill. But I am about to argue, and do maintain, that audacity supplemented by skill is irresistible, and my object is to arrive at some conclusion as to how your own Fleet can be best disposed so as to allow your audacity to produce the greatest possible effect on your enemy with the least harm to yourself.

I must now set out in order those points which, discussed in my last paper, or generally admitted, have, for the purposes of my present argument, all the force of facts, and must be acknowledged as such until they are controverted.

First comes the possible speed of a fleet in action: we know that this ranges between, say, eight and thirteen knots, and if I take a mean of ten knots, I shall place myself in such a position that half my hearers will say I put it too high, and the other half too low, a sufficient guarantee for being somewhere near the truth. Assuming such a speed, enables me to deal with the all-important relations of time and space; will permit me to show what can and what cannot be done by a fleet in the time allowed; and how the skilful commander may avail himself of the limit which time imposes on his enemy's movements.

Next comes the turning power of ships, which I showed in my last and former papers cannot be taken as to space, at a smaller arc than one with a radius of two and a-half times the ship's length; and as to time, a reduction in speed over the arc of one-third. It is perhaps necessary to repeat here that this statement does represent in the rough an absolute fact; and that the figures do give the smallest space combined with the least time in which average ships can turn. If the space be diminished the time will be increased, and if the space be increased, so also will the time.

If we now take 300 feet as the length of an ordinary ironclad, we get an arc of turning for the ships of our fleet of 250 yards, and a time of turning through (say) eight points at ten knots, of two minutes.

I must draw your particular attention to the foregoing figures, because I base my whole view of naval strategy upon them, not indeed on the exact numbers, but upon their relations to each other. These relations are, in my view, the bounds within which the strategist must work, and beyond which he will only fail in attempting to pass. It is no use to call them matters of detail or assumptions, they are vital principles; and the only assumption about them is the exactness of the figures. Ships may not be 300 feet in length, but the shortest turning ironclad which has ever been built, going at her highest speed, takes about a minute to turn through eight points on an arc whose diameter was 5·2 times her length, reducing her speed over the arc by more than one-tenth.

The next point to be considered is the gun-power of ships. I laid it down last year from the best data obtainable, that only about 10 per cent. of the shot fired from a sea-going ship would take effect upon another broadside-on, and at a fixed distance of 1,000 yards; and that the highest speed of fire which could be calculated on, was about one round in three minutes. The damage done by hits at that range was of course not easy to estimate, but except at close quarters, when the shot strike fair on the broadside, all allow it to be small: the effect of hits received when end-on is generally considered to be *nil*.

I held the ram to be the effective weapon in a single-ship action, the gun being subordinate, unless the Harvey torpedo should supersede the former; and while on this subject, I must say two words. I have usually in my papers stated that the idea of the ram originated in our Service, with the gallant Admiral of the Fleet, Sir George Sartorius. He will be pleased to know that another Officer, Sir James Sulivan, was, contemporaneously with him, pressing the weapon on the notice of the Government, and assisting in that development which we are yet so far from seeing complete.

Again, I have seen, since I last addressed you, the Harvey torpedo in action, and I have modified my views of it. It is not, in my opinion, so powerful a weapon as I formerly believed it to be. To use it effectually, special ships of high speed must be employed, and even then, much more skill is required than I imagined necessary. It seems to me also, that the mitrailleuse or volley-gun will be a very effective defence against this torpedo. It would be used both to sweep the manipulators off the decks, and also to destroy the torpedo itself. In any case, it must here be said that even when I read my last paper, I could not view the Harvey torpedo as an effective weapon in fleets. It is true that one or two special ships towing torpedoes, might, as an *avant garde*, throw a hostile fleet into some confusion; but, as the enemy might equally well employ the same weapon, we should have a combat of torpedo vessels between the fleets before they met, which could not lead to decisive results. If this torpedo is ever rendered powerless against friends, fleets might employ it with greater reliance on its power, against enemies.

I now arrive at a point on which there is not, and cannot be any data, but which universal assent has established as a fact. I allude to the general understanding that whatever formations may be in future

assumed by two hostile fleets in action, the ships composing them will always be end-on, and never broadside-on to the enemy. Some explanation is required to shew how I look on it.

In my last paper I endeavoured to shew that, prevalent as the notion was that the end-on position was that which a ram would assume towards another ship in action, it was in reality a false one. I showed that this was quite a right position for a ship *not* herself a ram, and desirous to avoid being rammed, but that if a ram were so to range herself she could never strike at an advantage. I find now very many Officers hold that I am wrong, not in upholding the advantage of making your stem take your enemy's broadside, but wrong in believing that two ships will seldom, or never, meet stem to stem. It is difficult to argue either side of the question, but I may note that the Russian gunboats never met stem to stem in their experiments; and I may express my firm belief that one or other ship will in such a case swerve at the last moment, and pass broadside to broadside without any result from either ram. Those who think otherwise must remember that there is no analogy between the old principle of getting broadside-on to your enemy at pistol range, and pounding him till either one or the other struck, and the stem-to-stem encounter between two rams. The superiority of the English seaman in our old wars lay in his muscle and his steadiness. The weakness of our enemies was never in material, but they failed in nerve and stolidity. It was the height of strategy to bring our strong points against his weak ones, and broadside to broadside did this in perfection. But for one ship to run against another, stem-to-stem, is no strategy, but rather a reckless blind trusting to chance.

The victory depends upon which ship turns out to be hardest, and the spinning of a teetotum will represent the chances on either side. The strong probability is that if two ships met at speed, stem-to-stem, the shock would be so terrific that both combatants would instantly disappear.

I am saying nothing here of the policy of charging straight down upon your enemy in the belief that he will flinch from his end-on position before the last moment, and give you the opportunity you seek. Such a course may be the most excellent strategy, as you are opposing your presumed strength of nerve to your enemy's weakness. I have before said, however, that I have nothing to do with strategy of this kind, and if a stem-to-stem encounter is contemplated in any other view, it will, I think, be a very foolish proceeding.

If there is anything to be said on the other side, I am not now aware of it, and I therefore base all my ideas on what I have here stated.

Those, therefore, who think with me, will observe the instinct of the naval world has led it to contemplate the end-on position for hostile fleets, not as the best means of attacking with rams, but as the best means of frustrating an attack of rams. Our opponents will take the opposite view. The latter party will maintain that the ram dominates and prescribes the formation, and is itself the chief weapon; I, on the contrary, conclude that the ram dominates and prescribes the formation

DIAGRAM VII

Fig. 2

Fig. 1

Fig. 3

Fig. 4

DIAGRAM VI

Fig. 8

DIAGRAM V.

Fig. 5

Fig. 1

Fig. 2

Fig. 3

Fig. 4

DIAGRAM IV.

Fig. 2

Fig. 1

which is so good a defence against it, that the ram is not the chief weapon in fleet actions. And the inefficiency of the ram as the chief fleet weapon, once the end-on position is firmly established, seems to me to be argued by other considerations which I have not yet seen treated by any writer on tactics.

If we examine the ramming tactics for single ships laid out in my last paper, and endeavour to apply them to fleets, we shall soon see, I think, their inapplicability. Take Diagram I, figs. 7 and 8, and Diagram III, fig. 1, of my former paper, and you will at once note that the

Fig 1.

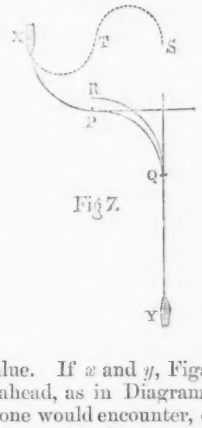

Fig 7.

Fig 8.

mode of approach is of small value. If x and y, Figs. 7 and 8, were leaders of single columns in line ahead, as in Diagram IV, fig. 1, it is apparent either that the leaders alone would encounter, or that the turn of x to ram, throwing her broadside open to the next astern of y, would be taken advantage of by that ship, and even if x succeeded in ramming y, she would herself be rammed in turn. So if x and y were the port wing ships of single lines abreast, as in Diagram IV, fig. 2, their manœuvres would have no reference to the remainder of the fleet. If x and y were not wing ships, but some other ships in the lines abreast, as in Diagram V, fig. 1, then x must make his turn astern of his left hand neighbour; he lays himself open to attack by y's left hand neighbour, and breaks the order of his own line, cutting himself off from support at the same time. Should he, however, use the short turn, as in Diagram V, fig. 2, his manœuvre will be baulked by his own left hand neighbour, to avoid whom he must exercise caution, and who more or less hides the object of his attack, just at the moment when all depends on his getting a clear view. He again lays himself open to the attack of y's left hand neighbour, or, if he misses y, of his right hand neighbour.

If x and y, however, being leaders of lines ahead, choose the 4-point method of approach given in Diagram III, fig. 1, the rest of the fleet does not partake in any of the advantages of the mode of advance, as may be seen from Diagram V, fig. 3. If, however, they were the leaders of columns in quarter-line, as in Fig. 4, their tactics would equally apply to the ships astern of them. But the difference is, that

x is no longer solely occupied with his attack. If his own next astern by any accident lets y's next astern slip past him, x has two ships upon him, and fights at a disadvantage. We see running through all these positions a principle by which, in formation, one ship covers or guards another from a ramming attack, and renders useless the methods which are available between single ships. The fleet which rigidly maintains its end-on position, and whose ships only swerve from that to deliver their blow upon the enemy, who presents his broadside while attempting to ram the ships to whom they are guards, goes into action with an advantage, for it runs no such risks of being rammed as its opponents who seek to attack in that manner, and while it never drops its own guard, it is ready to take advantage of any slip its enemy may make.

Naval strategy, therefore, while it dictates an attack by the ram by single ships as the most effective means of obtaining the victory for him who is most skilful, does not seem to me to advise that policy in a fleet attack. You must beat your enemy in some other way.

Before leaving this part of my subject, it is necessary to point out that some ships in every formation have no guards, and are open to the same attack as single ships. The rear ships in line ahead are open to the ramming attack on both sides; and the wing ships in lines abreast and quarter lines were open to attack on their outer sides. Hence, although you cannot, as it seems to me, make your general effort a ramming attack, you will be foolish to avoid any opportunity which offers of attacking particular parts of your enemy in that manner.

We are now in a condition to apply the principles we have brought out to the actual business of my paper, the Attack and Defence of Fleets.

In all sea-fights of former ages, we see either of two conditions; both fleets equally ready for the combat, or one assuming from the outset the attack, and the other the defence; the former condition is rare. Hitherto, I believe, no case has occurred where—as in so many battles on land—a skilful movement has converted the defence into an attack. The most that could be done in former times was practised by the French, before the revolutionary war, in taking advantage of the weakness of the British attack to damage them seriously while keeping themselves out of harm's way. Clerk of Eldin shews that in the attack from to windward, generally practised by us before Lord Rodney's victory changed our views, we really offered a portion of our fleets to the whole fire of the enemy, as shewn in Diagram V, fig. 5, and the van becoming disabled from this cause, the French were in a position to bear away to leeward to re-form, and to repeat the manœuvre, which they usually did.

Sir John Jarvis at St. Vincent, and Lord Nelson at the Nile, are brilliant examples of an opposite mode of proceeding, and though the approach of Lord Nelson at Trafalgar might seem a recurrence to old methods, it was not really so, as the enemy's fire was divided between two vans, and the approach was direct, and as rapid as it could be, instead of the slow and "lasking" approach, as it was called, shewn in Fig. 5, Diagram V.

In the changed condition of things now, we must be very careful to guard against following history too blindly as our guide; but, at the same time, we must by no means neglect to avail ourselves of the lessons she really teaches; though, therefore, the *manner* has passed away, the *matter* remains as worthy of adoption as ever it was.

I think now that steam has done much to alter the former state of affairs, and that an inferior fleet may, when direct attack is not at first attempted, convert a defence into an attack, and perhaps even gain a victory.

The principles of a skilful attack or defence must ever remain the same; they must always be the offering a superior force to an inferior; and if a part of the enemy's fleet is made to bear the brunt of the whole of your own, the greatest strategist can do no more.

I am sorry, however, to believe that we are at present drawing more inspiration from the manner of our forefathers in naval tactics than from the matter. I do not think we have shaken ourselves sufficiently clear of the traditions of naval sea fights to perceive the laws which underlie them, and become applicable to our own times. In days of yore we had a broadside position; small sail; and low speed. Now we have the end-on position, and great speed. I do not think, from all I have seen and heard, that naval minds habitually dwell on the speed at which future actions must be fought. It is known and acknowledged that a ship without speed, if met by a ship with speed, is doomed to certain destruction by ramming, but in spite of this, the picture of a fleet action naval men have before their eyes, is always a confused assemblage of ships more or less stationary. It is quite common to hear it said that "the best tactics are for every captain to put himself alongside an enemy's ship," as if such a thing were now possible, unless the enemy's ship were a consenting party. The French system of tactics did much, and Lissa did more, to confuse the picture of a future sea fight, and to paint it as a *melée* of independent attacks. The *melée* at Lissa was entirely due to the broadside position of the Italian fleet, and its want of speed; two concomitant blunders which no commander will ever be mad enough to bring together again. Had it been otherwise, Tegethoff might have had his *melée* to himself, but the Italians would have been out of it from their own impetus. If two fleets charge one another at ten knots in the end-on position, three minutes will elapse between their being a mile apart and their meeting, and in another three minutes they will again be a mile apart. If the very instant after one fleet had passed through the other, they put their helms hard over, still the other fleet would be three-quarters of a mile away before the first was in pursuit. Under such circumstances the only *melée* will be amongst the wounded birds, and the type of the battle would be a rush, a contact, a separation, a re-formation, again facing each other, another rush, and the same thing repeated.

The other type of action—still due to speed and the end-on position, would be where one fleet retires before the other until, by happy skill, or by happy accident, it is able to face its pursuer with advantage.

How to face your enemy with this advantage, how to bring your

whole fleet on a portion of his when facing him, seems to me the problem before us.

We shall all be agreed, I think, that anything like elaborate manœuvring is out of the question, except in the process of retiring. The mere moment of time which elapses between the coming into range of two approaching fleets and their shock, renders either manœuvring or signalling absolutely out of the question. Nay, even after sighting an enemy's fleet—say ten miles off, he will be a hardy admiral who attempts to do more than throw his fleet into the formation he intends to fight in. In such circumstances, the fewer signals the better, as a mistake might be fatal, and the chances of mistake are trebled when the nerves are tightly strung, as they would be at such a moment of excitement.

The very numerous, and sometimes eccentric, fighting formations which are proposed for adoption by our own and other Navies, may be classified under four heads; which, on still closer examination, may for the purposes of argument, be resolved into two. These are—

(1). An extended front, with small depth.
(2). A narrow front with great depth.
(3). The mass or square, where depth and front became equalised.
(4). The system of groups, however, disposed. The principle being that the attack or defence is not concentrated, each group making itself felt as occasion offers.

The mass, or square, must possess in a less degree the advantages and disadvantages of the extended and narrow front, and of the small and great depth.

The groups must be disposed either along an extended front or along an extended depth, and, therefore, must, so long as they remain in formation at all, possess the weakness or the strength of those formations.

If, however, we reflect a moment, we shall see that when an enemy's fleet is approaching in an order of battle, all that can be detected in the few minutes of time allowed, will be either its extended front, or its extended depth. Therefore, although if time permitted, I might go into greater detail, I think that I shall best argue out the principles I have in view by imagining all formations classed under the two first heads, and considering the relations between an extended front, as opposed to an extended front; a narrow front and great depth as opposed to an extended front and small depth, and a narrow front and extended depth as opposed to the same formation. A few words will then suffice to treat of the mass or square, and of the system of groups.

It will also, I think, conduce to clearness, if I do not go beyond the two representative formations of the extended front and the extended depth, namely, the single column in line abreast, and the single column in line ahead.

The attack I define to be when the ships keep their heads towards the enemy, advancing, or trying to advance on him. The defence is when the fleet retires before the enemy.

In the attack there is always one enormous advantage on the side of that fleet which takes the initiative. Ships cannot move simultaneously, except by signal. One or two ships may turn so closely after each other, moved by a common impulse, as to be practically simultaneous in their action; but this cannot be carried throughout a fleet. It follows, then, if there is not time to make a signal after the nature of the attack is disclosed, neither will there be time to manœuvre so as to counteract it. The Admiral assuming the initiative, or advancing in such a way as enables him to assume it without a signal, may do so with some security against a counteracting movement. While he who waits till the attack is developed in the hope of counteracting it, runs the risk of not being allowed time to do so.

Taking, now, Diagram VI, we have two fleets 2,000 yards apart approaching at the rate of 20 miles an hour. The fleet A may pass straight on, bearing down upon B, without alteration of course. In the three minutes elapsing between getting into range and contact, one, or at most two rounds may be exchanged. Supposing both fleets had been stationary at 1,000 yards, and each ship in A fired two guns at B, between one and two shot might strike, with a chance of penetration or damage at its minimum. But the fleet target, so far from being stationary, is altering its range eleven yards in a second. Under such circumstances, to fire is to waste powder A had better proceed without firing and with his guns concentrated right abeam and horizontal, ready to discharge point-blank into the enemy in passing, should his ships maintain their end-on position and so elude the ram. B, under present circumstances, ought to reserve his fire, and hence, when the two fleets have passed through one another, they will have fought on an absolute equality, and any less damage done to one or the other must be due to stronger plating, bad practice on the other side, or the chapter of accidents.

But, consider how very dangerous this method of engaging will be to the friends on both sides. In the confusion, excitement, and smoke, how more than likely is it that a friend will receive the broadside intended for an enemy? True, each fleet runs an equal risk of this, just as each runs an equal risk of being rammed. But to run these risks is not strategy, and it is, I think, plain on these grounds that an attack made direct, by an extended front, ought not to be met by a counter attack of the same nature.

It will be open to A, if there is time to make the signal before getting into range, to put in force the application of ramming tactics formerly mentioned, and by altering course together four points either way, to endeavour to force a similar movement on the enemy, and thus to convert an artillery combat into a trial of skill in ramming. If this movement were made at the moment of coming into range, the new positions of the fleets would be at p and q. It is pretty clear that A's manœuvre has no forcing effect whatever on B, who, on the contrary, appears to have certain advantages placed in his hands which he had not before. It is true that, for a moment, the artillery of A may be held superior to that of B, inasmuch as he can probably bring more guns to bear. But this advantage passes away as A moves to the right

along the front of B, and besides, A receives the shot of B more directly perpendicular to his broadside than does B those of A.

But while the port-wing ship of B is guarded from rams by her right-hand neighbour, the port-wing ship of A is not guarded at all, and should be the object of B's attack by ramming.

Except these alterations of course together, which must be ordered by signal before getting into range, there appears little that A can do so long as he remains in line abreast; and if it be as appears, that he gains no advantage either in a direct advance or a four-point advance, it seems to me he must give up the extended front if he wishes to attack an extended front with an advantage.

Let us therefore examine the extended and narrow fronts as opposed to each other. This we have in Diagram VII, fig. 1. We suppose two fleets, A and B, observing one another at sufficient distance to allow of consideration and to the coming to the conclusion to attack: but A determines to do so in a formation with a narrow front and B with an extended front. The headmost ship of A has approached to within 2,000 yards of B's ships. Let us see how matters stand between them. A's leader is open to the fire of the whole of B's bow guns, a fire which we have before shewn to be ineffective. That is her whole disadvantage. On the other hand she is within three minutes of contact with B's fleet, and yet has not disclosed the nature of her attack. Supposing the Admiral of A to be leading, his orders would be to the ships astern of him to follow his motions *together*, as nearly as possible, to concentrate their guns at point blank, right ahead, and to pour in their shot on the instant of passing an enemy's ship.

A has three attacks open to him: the centre or either flank of his enemy, and leaving him in doubt up to within three minutes of commencing his attack, it is manifestly impossible for B to counteract him even if there were a movement capable of doing it. Suppose A chooses to pierce the centre, and therefore simply continues his course; as he passes between two enemy's ships he certainly receives their two broadsides; but if he be equal in power on both sides he gives them as good as he gets, with this advantage, that his shot which miss one enemy's ship may hit another; while the enemy's shot which miss him may damage their friends. But if A's leader has already been subjected to bow fire from those ships between which he passes, they will hardly be ready in the time to give him broadside fire as well from these guns. But in any case, the moment A's leader has exchanged broadsides with her enemies, and long before they are in a condition to fire again, a succession of fresh ships pass into her place at the rate of one every twenty seconds or thereabouts. The two ships between which A is effecting his passage will thus receive five broadsides apiece in about a minute and a half, without more than a single reply, and if this is not enough for them, I think it ought to be.

Here we have the process of "doubling on the enemy," as I conceive it must in future be practised. The principle remains the same as ever, only the detail has altered with the times. Instead of doubling simultaneously and so placing a ship betwixt two fires, we must now

double in succession, serving him with a continued succession of fresh ships.

The only objection I can see to this centre attack is, that you lay yourself open to the fire of both flanks on your near approach, whereas, by attacking on the flank, you can receive no more than half that amount.

In this attack, if the Admiral chooses to threaten the centre till close up with the enemy, which I think will be hardly necessary, his ships should turn together towards the intended flank and then turn again into line ahead, as shown in the diagram, pouring in successive broadsides into the enemy's wing-ship in passing. A's rear ship should, I think, be directed to attack the wing ships of the enemy with his ram, and for this purpose should steer further out than the ships ahead, so as to give himself room to turn. His orders should be not to embroil himself by making a second attempt if he misses the first,—indeed, he can hardly obtain a second opportunity,—but to follow the rest of the fleet, which should re-form with their heads again towards the enemy, ready to act again as may be necessary.

There are in this kind of combat a variety of circumstances to be noted which seem to me to tell in favour of A's attack. If there is no wind, A's ships after the leader, will observe B's wing ships emerging from the smoke of their own and A's guns, before they themselves have entered it. They will consequently be more masters of the situation than B's ships can possibly be. If B's whole line continues to fire from his bow guns, as no doubt he would, there is the greatest danger of his line getting into confusion, and also of some of the shot intended for an enemy reaching no further than a friend. It is, I believe, a fact that with modern heavy guns the compasses are thrown completely out of gear, so that no formation can be maintained by compass while firing.

In A's advance the compass is not appealed to at all, as each ship simply follows her next ahead in the closest possible order; and although the formation will probably be broken ultimately, this will not happen till its work has been done, and it is clear of smoke in rear of the enemy.

If the wind were blowing towards the attacked flank across the enemy's front, his view will be interrupted, and his fire will slack. But the smoke may also shroud A's ships from one another even before they fire, and their broadsides may be thrown away.

If the wind is from the attacked flank A will always be in the clear, while the ships of B's line will be shrouded, each one by the smoke of his neighbour.

I think, therefore, that A should choose the weather flank for his attack. If the wind be with B's fleet, so much the worse for him, while it will not affect A. While, if the wind be with A's fleet, the conditions will be those of a calm, except that A will be longer in his own smoke after he has passed the enemy.

But while showing the advantages of thus opposing a narrow to an extended front, we must not omit to ascertain what possibilities of

defence lie in the extended front. At first sight, many movements will suggest themselves as practicable, but when we apply the rigid standards of time and space, we shall think differently.

Remember, there are but three minutes in which B must form and execute his plan. On the face of it, therefore, there can be no combined manœuvre not previously arranged. No previous arrangement could embrace more than a single movement, yet there is no single movement preserving the line abreast, which can be executed in the time and space except by surrendering the attacking position.

Suppose B were to hope to swing his line round on his port wing-ship as the pivot? To do this, the port wing-ships, the very object of his solicitude, must reduce their speed, enabling A's rear-ship, already warned, to ram them with ease. But in no case can B's starboard wing-ship come upon A's rear-ship in time. Again, B surrenders his bow-fire in attempting any manœuvre, for it is admitted by all impossible to manœuvre in smoke. Besides, any one who has experience of fleet manœuvring, is aware of the difficulty of preserving the formation when swinging round, even for drill purposes.

Single ships, it has been said, may pierce A's line or ram him. This is so, but only by passing astern of their friends, and so separating from them and plunging into the midst of their enemies, can they effect their purpose. But then they pass at once into the heaviest of the smoke, and run at least as great a risk of destruction themselves as they bring upon their enemies.

On the whole, therefore, my view is, that an extended front is an exceedingly weak formation for attack, and ought to succumb to the narrow front in all cases where things are otherwise equal.

But the extended front may, when time permits, be changed for the narrow one. If B, surrendering his idea of the line abreast, were, on perceiving A's approach in line ahead, to meet him in the same formation, he would advance his port wing-ship and form astern of him.

This would give us the narrow front as opposed to the narrow front, shown in Diagram VII, fig. 2, and I think we see the balance is restored, and that if both fleets so advance, they will fight on an equality.

It is of course useless, and perhaps foolish, for the leaders to open fire till abreast of each other; they will then exchange their broadsides, and if they both pass on, will each receive the broadside of fresh ships before they can reply effectually. Here the same qualities might stand the British seaman gunner in as good stead as formerly, provided, that is, that machinery more perfect for working guns is not adopted by other nations, and a rapidity of fire obtained, which we cannot compete with.

But without this, or in spite of this, A may by proper orders to his ships, gain an advantage over B.

Suppose, for instance, that A's leader, and each ship astern of him, were ordered the moment they had fired their broadsides, to turn sharp off to starboard, B's fresh ships would never get the opportunity of firing at all, and his leader and her next astern, would have

received the fire of the whole of A's ships. When the smoke cleared away, A would find himself in quarter line with B in his rear, and might determine on the next stage of his attack.

I have now discussed as closely as time permits, the principles of Naval Strategy in the attack as they have presented themselves to me after such limited examination as I have been able to give to them.

It will be seen that I believe the extended front to be a weak formation, and that in no case should it be taken up in an attack. It has appeared also in the course of my enquiry that the bow-fire, on extreme training of guns, is not of great value, and that more is to be done by broadside fire in attacking fleets. These conditions appear reversed when one fleet retires before another. Then, unless the pursuer can enforce by his speed, or the pursued takes up for himself, the position of attack, the result must depend on the goodness of the gunnery practice. The pursued must spread out an extended rear, and the pursuer an extended front, in order to get the full value of their artillery. Here the distances will be fairly permanent, and the bow and stern fire becomes effective. I cannot conceive, however, a decisive victory gained on such principles; and for the defence, I would rather convert it into an audacious attack upon either flank of the pursuer in the manner before described.

I have already stated that if a formation, such as the hollow square proposed in Russia, possesses depth and extended front in combination, it possesses also the weaknesses and strengths of each quality, and therefore, if the better qualities of the line ahead be opposed to the less good ones of the shorter side of a square, there will still be an advantage, though not so great on the part of the former.

These compromises seem to me to be proper for adoption by such nations as, from their want of naval prestige, may be more solicitous to guard against defeat than to ensure victory. I must own my sympathies lie in the direction of audacity, and a determination to win all or to lose all; and hence I do not so much concern myself with half measures.

It will be seen that I lay great stress on compactness and concentration in attack, and I am in consequence opposed to systems of reserves of separate fleets acting conjointly, or lastly to the attack or defence by groups.

I cannot at present see how, when fleets are at speed, a group can act independently without running the great risk of finding itself surrounded by enemies and beyond the support of its friends. Suppose a group such as Figs. 3 and 4, diagram VII, opposed to even the same number of ships only, in close order in line ahead. The broadside fire of one ship in each formation is masked, and in Fig. 3 the attacking force of three ships would receive one broadside from the leader at double distance, and one from the wing-ship at close distance. But this wing-ship would get in return three broadsides at close distance. So with four ships in line ahead attacking the group of four. The leader might sustain one broadside at close distance, and two at double distance. But the wing-ship would sustain four broadsides at close quarters. Then observe the weakness of these groups in the

matter of ramming. Fig. 3 has two ships out of three, and Fig. 4 three ships out of four, unguarded. Such an opportunity for the ram-ships of a line ahead is all that can be desired, especially in Fig. 4, for the ram which misses the wing-ship, will almost to a certainty catch the rear.

Such, then, is my slight summary of the line I conceive our study of Naval Strategy should take. I should be very sorry, indeed, to dogmatise on a subject which is to all intents and purposes a new science, but I hope to have shown that there are sound principles to be got at even in peace time, if we will only take sufficient trouble to find them.

Commander DAWSON, R.N.: I hope that nothing may occur to this Institution to prevent for the future our having the pleasure of receiving information from the lectures that are occasionally given here upon the principles of "naval tactics;" for I do not know where else we should be able to gain any information upon that subject. It is true we have a Naval College at Portsmouth; but I am not aware that there is any Professor of "naval tactics" there. I understand that at the Military College there is a Professor of "military tactics." We have heard of a "Professor of military history" at that college; but I am not aware that there is any "Professor of naval history" at the Naval College. There is also a "Professor of artillery" at the Military College; but not one at the Naval College; even naval architecture is not taught there, so that we are really dependent upon this Institution for any information that we may obtain as to the principles of naval tactics, naval gunnery, and collateral subjects. Turning from this subject, I remark in this paper that there is not a single fact brought forward showing that the British Fleet, which costs so much, has done anything to elucidate any of the questions which arise in determining the best way of using the various novel ships and weapons with which it is furnished for purposes of war. I do not mean to say that the Fleet has made no experiments, practised no war-like manœuvres, or gathered no useful experience, but I merely draw attention to this circumstance, that if any portion of the Fleet has elaborated experimentally any facts bearing upon future wars, they have not been brought forward now; and, as far as my information goes, these experimental or other experiences have not been communicated from that necessarily small portion of the Fleet which may have gained the knowledge, to the Officers of that other larger section of the Fleet which has had no opportunity of acquiring it for themselves. Nor do I believe that there is any means in existence by which such experience can be communicated from those who gain it, to those Officers afloat who have not that opportunity. This waste of experimental experience and professional knowledge is a very important point, to which I wish to direct attention. Passing from the absence of facts, it appears to me that the future tactics of the Navy depend upon the relative values of the weapons with which we are going to fight. I concur with a good deal, in fact, I almost entirely concur with what Captain Colomb said as to the dangers that may be anticipated from, and the skill which is required in, the use of the present Harvey torpedo in a general engagement. That is one of the things which it appears to me ought, in time of peace, to have been long ago found out by the Fleet and remedied. The Harvey torpedo has been spoken of before the world for twenty or thirty years, and was adopted as a fighting weapon for the British Fleet about two or three years ago; so that Captain Colomb ought to be able to say that the Channel squadron, and the Mediterranean, the detached, and other squadrons, as well as single ships, have during those three years handled these Harvey torpedoes in every possible way; that they have found out that such and such is the case, and that such and such is not the case. Again, it is twenty years ago since Sir George Sartorius and Sir Bartholomew Sulivan advocated the employment of the ram, and for the last ten years every ship built for the Navy has had her bows fortified and armed for ramming; yet we are theorising on the subject to this hour, without a single ascertained fact being produced able to show that any British ship or squadron has done a single thing to elucidate that subject, or that a single British Officer has gained an atom of

experience in this weapon with which so many of our ships are provided. We are obliged to go to Russia to find out what the ram can do, and to borrow the practical experience of the Russian Navy; the captains of which are regularly trained to its use. I am one of those who think that the Harvey torpedo is right in principle, and that a little money for experiments, a little experience, and a little talent applied to it, would make it a very safe and a very destructive weapon. But, even taking it as it is, it is a very formidable weapon. Look at that diagram No. 6, showing two fleets in line abreast meeting end-on. Only three minutes will elapse after coming within range of fire, before they meet. If at the beginning of those three minutes the ships of one fleet, or of both, were to extend a Harvey torpedo on both quarters, and were to still continue their courses, the consequences would be something fearful. If the Harvey torpedo in its present condition is not powerful enough to break through an armoured ship at the water-line, I do not see any difficulty in enlarging its capacity and introducing a detonating explosive which will readily do so. If we do not employ the torpedo, the Russians will, and I should advise them to put a little more dynamite or gun-cotton into it, and make it powerful enough to perforate armour plates at the water-line. The Harvey torpedo might be doubled or trebled in capacity without any great increase in dimensions and without losing its handiness. As to its safety as regards friendly ships when employed in a general action, I see no difficulty in the application of electricity to the Harvey torpedo as the igniting agent, and then it would be absolutely innocuous upon accidental contact with friendly vessels, as it could only explode at the will of the operator, who would not make the connection with the electric battery till he saw the torpedo approaching a hostile ship, and the wire could be disconnected on a failure to make contact. As to the risk to the torpedo-operators from artillery or Gatling-gun fire during the three minutes that the two fleets are approaching under fire, I do not think it would be very much if the vessel operating was an ordinary ironclad, armed as usual with guns. The difficulty is one that the Fleet ought to have experimented upon and determined long ago. In the absence of practical experience on the part of our Navy, my opinion is that there would be no difficulty, providing there was suitable cover for the operators; and if that was done, the danger from artillery or Gatling-gun fire would be overcome. At any rate difficulties are made to be overcome, and it ought to be the business of the Navy, as a training school for war, to attack and conquer them, and what better training for war than that our sea-going Officers should experimentalise upon their weapons, record those experiments, and communicate their failure or success to the rest of the Navy? Believing as I do that a good deal may be developed out of improved naval torpedoes, and that torpedoes in one form or another will be used against us in the open sea, whether we employ them or not, I think the torpedo will govern the tactics of the Fleet; though, when both sides are armed with it, it will only serve as a defence against rams and against hostile torpedoes, and will thus become a defensive rather than an offensive weapon. It will be utterly impossible for one ship to pass within 200 yards of another vessel towing Harvey's torpedoes; and, if both sides are equally armed, fleets must keep at that respectful distance. Hence it follows that fleets will not attempt ramming, because they cannot approach within 200 yards without mutual destruction. The action will then resolve itself entirely into an artillery contest. Now, we have made tremendous strides in artillery of late. It is only six years ago that we were told by the highest seaman-like authorities, that it was utterly impossible to work guns of more than six tons weight on the broadside. We are now able to work 25-ton guns upon the broadside. The 12-ton guns can be fired once every minute, whilst the 25-ton gun can fire one shot every two minutes. Nothing could be more efficient or more secure than the means by which these ponderous guns are manipulated, so far as training, running in and out, and elevating is concerned. The mounting of guns has a large influence upon their accuracy; a smooth, regular, yet rapid movement assisting the aim very considerably. But the loading arrangements are exceedingly slow, clumsy, and unsafe, and might be much improved, which would increase the rapidity of fire. We were told by Captain Colomb in his former lecture, and I quite concur in the observation, that the accuracy of the fire of our few heavy rifled guns is very small; that not above one shot in every ten was expected to hit the mark. Now, accuracy of fire is a question which it is the province of naval gunners to be able to deal with. I am

sure if good sea-shooting was a military question, we should have had three or four committees appointed, who would have experimentalised for years upon it, and we should have had a great many blue books and exact records of several thousand rounds to refer to; but as it is a naval matter, we have no information upon the subject except the one experiment in the Channel squadron, which Captain Colomb has quoted. Now, good shooting at sea depends, amongst other things, upon knowing the range, Admiral Ryder elaborated tables and methods for ascertaining distances, twenty years ago; and to this day there are no means taken to give effect to those tables and to carry them out by stationing people for the purpose of observing the distances, except when firing at a target from the larger ships. It ought to be done to all vessels on every occasion of going to quarters. There is another serious difficulty in the way of obtaining accuracy of fire under lively rolling motion at sea, and that is that the new rifled guns are very badly sighted. The old 68-pounder in a lively sea can now make better practice than one of our 9-inch rifled guns. This arises from the new guns being so badly sighted, the smallest visual error in taking aim having a much greater effect upon the range than a like visual error in the old guns, owing to the decreased distance between the rear and fore sight in rifled guns. On ordinary occasions the line of vision of the captain of a gun standing six or eight feet from the rear sight, must pass above the tangent sight. The vertical height which the line of vision passes above the rear sight constitutes a visual error, which is the cause of all large errors in the range, when firing at known distances. This visual error may be taken at two-tenths of an inch at ordinary times, but, when in lively motion, the shot falls 300 or 400 yards beyond the target, the vertical visual error is evidently considerable. The value in range due to a given height of line of vision above the rear sight depends upon the distance between the two sights. A visual error of half an inch over the tangent sight—not a very large one to make with lively motion—will, in the 68-pounder, amount to about 180 yards at 1,000 yards' range; but in the 9-inch rifled gun it amounts to more than double that distance. And if the dispart sight be removed, the difference between the two would be such that the 68-pounder would, at 1,000 yards' distance, make about one-fourth the amount of difference in the range for that half-inch visual error. This has an important influence on good shooting from lively ships. The power of the guns may be very much enhanced by a better system of rifling. The present system of rifling altogether fails to give rotation to long shells such as the guns are designed to project. Instead of employing a known system which will give the necessary rotation, we reduce the weight and capacity of the projectile, thereby sacrificing one-fifth the weight and two-fifths the bursting power of the 11-inch guns, and one-half the shell power of the new 35-ton gun. As guns are reduced in number, it becomes more essential to study the effective use of individual guns, and we can scarcely afford to sacrifice so much of their naval efficiency to a bad system of rifling. If I am correct that future naval tactics must be directed to the most effective employment of artillery fire, then the improvement of artillery fire is brought into greater prominence than ever, whilst in our more recent constructions, the number of guns carried has decreased so very much. Many of our older ironclads want re-arming, their armaments being incapable of penetrating the newer vessels. There is no essential connection between weak armour and weak guns, and no reason why an "Agincourt" should not perforate a "Hercules." In the confused *melée* of a general action, it is impossible that hostile ships should seek out the one carrying corresponding thickness of armour, even if the thickness was legibly marked on each broadside. Without dwelling any longer on the subject of guns, it still appears to me that "tactics" depend upon the weapon you make use of. Captain Colomb has thrown over a most important weapon—the gun, and has based the principles of tactics upon its non-employment in general actions. If that weapon is a reality, then all his principles of tactics are wrong; if that weapon is not a reality, then the principles of tactics enunciated are right. I am sorry that in such vital questions, speculative opinions can alone be advanced in discussion on one side or the other, instead of our being able to deal with ascertained facts. It would be far more satisfactory to be able to say that so many ships had under so many different conditions, made such and such experiments with such and such results. But in the general ignorance which obtains afloat as to the capabilities of

modern ships and weapons, I cannot point to the experience gained, but must deal only with speculative reasoning. I want to clear away the ground as to the weapons to be employed, in the hope that those who follow me, and who may have had more experience than I have in antiquated parade fleet movements, may tell us, in the case of a fleet so circumstanced that artillery fire is to be the deciding weapon, and that ramming is rendered impossible because of the use of a safe and powerful torpedo, what are the tactics which should then be employed.

Admiral of the Fleet, Sir GEORGE SARTORIUS: I wish to make one or two personal observations with regard to what Captain Colomb has said as to the priority of advocating the ramming principle. It is an old principle. I never dreamed of taking to myself the claim of originality in the matter. It is one of the first things we learn at school in reading of the naval battles of old, the ancient mode of fighting with the ram prow. I was commanding a ship when steam was introduced, and one of the first things that struck us, the young men of those days, was the possibility of introducing the ramming principle through the aid of steam. But there, one soon saw the formation of the ships, and the sail-power unfavourable for the purpose, and that the bowsprit, the cutwater—the two latter were so many buffers to deaden the action of the vessel—whilst the ramming ship would be completely exposed to the raking broadside of the ship attacked. For the time I gave up the idea. It was during the Crimean war, when the French floating battery arrived out—a vessel worked equally under sail or under steam, and at the same time invulnerable;—that it struck me that the moment had now really arrived, when the principle of the ancient ram could be reintroduced. And it was in 1854–5 that I wrote to the Admiralty my views upon the subject, and pressed for a Commission to examine into it.* I shall, however, say nothing more upon that point. With regard to the theory that Captain Colomb has laid down, there is a great deal of excellent good sense in it. It is very necessary that some good theory should be now formed upon the management of fleets and ships and future war tactics, based upon the best materials we actually possess in order to prepare and be in readiness for contingencies before they arrive. The attention of Naval Officers cannot be too constantly kept on the alert on this most important subject. A well based theory once formed, the subsequent perfecting of it becomes a far easier task. I agree also with Captain Colomb that the torpedo is, apparently, a formidable weapon, but when it comes to be brought into practice in actual warfare, there are so many circumstances required to unite, to make it act with certainty, that you could not depend upon it, particularly by the broadside attack. In my opinion no vessel can be better fitted for using the torpedo than the ram, properly constructed. According to my idea, the ram ought to be exceedingly rapid, exceedingly handy; therefore, no other vessel could be better fitted for using the torpedo. In a general naval action it is hardly possible that the torpedo can be depended upon or used with any certainty or safety. You cannot

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* Sir George Sartorius has requested that the accompanying note may be added to his remarks:—

Extracts from Letters addressed to Sir Charles Wood, now Lord Halifax, in November, 1855.

"Let me earnestly draw your attention to a fact which I have no doubt has presented itself to many other minds before, viz., the use of steamers as battering "*rams* for sinking ships. The successful experiments of iron plated ships has now "removed all objections to, and renders perfectly safe, simple, and efficacious, this "mode of warfare," &c., &c. "Let me suppose a steam vessel built without a port "or a single gun with great longitudinal strength, that being the direction in which "the blow would be given, with bow built in with massive timber, and the vessel "covered with iron plates of sufficient thickness to resist that. Then with an "engine of 1,000 h.-p. at a speed of 15 or 16 knots, could there be a moment's doubt "as to the fate of the largest ship when the concussion took place?" &c., &c. "If "the Russians are not able to build these vessels, they will be able to manage it in "the United States.

"The Confederates carried out exactly these suggestions in the 'Merrimac.'"

calculate upon the necessary velocity with which the ships must move to apply it in the way that Captain Harvey proposes, particularly if the ship attacked is well armed and swift. I do not say that by-and-bye we shall not come to other modes of using it; but under present circumstances, I think you can never depend with much certainty upon it in a general action. Then, again, I do not think we shall have many fleet actions in the future. The circumstances of former wars, and the blockading of great ports, made it necessary to have a large assemblage of ships to blockade them. But the whole system of naval warfare is now so utterly changed by the introduction of all these new modes of attack, new forms of vessels and guns and torpedoes, that the assemblage of fleets will be unnecessary, and therefore it will be quite a rare chance, the formation of fleets. Our attention ought to be more turned to actions between two or three vessels, or between single vessels, with the ram and with the torpedo vessels if you like. But I think it will be a most extraordinary circumstance if two large war fleets should ever meet again.

Commander the Hon. E. DAWSON: Having of late years turned my attention a good deal towards the manœuvring of fleets, and having had opportunities of observing the practical application of certain theories of fleet manœuvring, I venture to offer a few remarks on the subject of the lecture which we have heard this evening. I would refer first to diagram 6. In this diagram two fleets are represented approaching each other in line abreast. Captain Colomb proposes that A should alter his course in order to avoid the approach of B end-on. Theoretically, certainly, that might appear practicable; but I maintain that any one who has seen two fleets approaching each other end-on, like that, would consider A a bold man if he altered his course as represented in that diagram.

Captain COLOMB: Are you speaking of diagram 6?

Commander E. DAWSON: Yes.

Captain COLOMB: I do not recommend that.

Commander E. DAWSON: That would apply equally to diagram 7. If A was placed in the position shown in the diagram, I cannot think he would ever have the boldness to make a signal to his ships to alter his course simultaneously to starboard, so as to attack the port wing ship of the enemy advancing in line abreast. If he were to advance in a line in which Captain Colomb has originally placed A, I think he would have a much better chance of success. But I do not think any manœuvre is practicable within the space of three minutes, as described in the lecture. Having taken the times of a great many manœuvres, I do not think it possible that any fleet can make any manœuvre successfully under at least fifteen minutes. I do not think it would be advisable for any Admiral to make a signal to attempt to do so. It could only be done by previous understanding with the Captains of his ships. Next, as regards the torpedo, I think at present the torpedo cannot be an efficient weapon for resisting the attack of a fleet or for attack. At the same time, I cannot but think that its power will be very much developed in future years. A fleet attacking in line ahead could not use the torpedo to the same extent as a fleet attacking in line abreast. It is all very well to assume that a fleet in line ahead will pass through a fleet in line abreast. The first ship may succeed in getting through, but the second or third ships would stand a great chance of being rammed by the ship nearest to them; and that would not improbably throw the fleet into disorder. The fleet in line abreast would probably have ships astern on each wing, that would operate upon the ships that pass through. With reference to the *pelotons* or groups, the *pelotons* appear in some ways to be a very good formation. At the same time, I prefer four ships to three. On two fleets approaching, say one in single column in line ahead, and the other formed in groups (pelotons) in line ahead, you may assume that the line ahead will attempt to pass on one side of, and not through the groups, in which case the argument of Captain Colomb would be perfectly correct, that one ship's fire would be lost, provided always those ships kept their stations correctly. But those who have seen fleets manœuvring even in peace time, will agree with me that two ships seldom keep their stations exactly in line abreast. It is very seldom that it is possible to do so; and when you have the smoke of an action, it is quite impossible it can ever be done. Equally so, I may say, more so, with a fleet formed in one column in line abreast. You may lay it down in theory that the ship that passes through the column first will receive the fire of only two ships; but, practically, she

will receive the fire of nearer four, because those ships will not be exactly in line abreast as they are there described in the diagram. As regards the torpedoes, I think at present it will not be practicable to work with them; but in future years I am convinced we shall be able to use them much more efficiently than at present; that they will form a great obstacle, and if not a great obstacle, they will be a deterrent to two ships approaching each other and trying to ram each other, because of the fear of a torpedo being towed astern.

Lieutenant HUBERT GRENFELL, R.N.: In addressing you I should like to speak with that modesty which is due from a junior member of the profession. At the same time I should like to express that opinion which I know many members of the profession entertain, I mean the opinion which was expressed by Captain Dawson that these questions of the day should be more thoroughly ventilated, and put in possession of the junior members of the profession. At the present moment we feel a great many difficulties in that respect. We have received a very able lecture to-night from Captain Colomb on "fleet manœuvring." I can hardly say myself how many times these things have occurred to most of us who are working in the same way, but, of course, with inferior opportunities. We wish very much to push forward, as far as possible, the profession to which we belong. I may say that, being out with the combined fleets the other day, when they all assembled for manœuvres, the first question almost which rose to the lips of every Officer who was on deck, when they first saw that splendid array of ships on the horizon, was, how should such a collection of ships be arranged for attack or defence? We were present during the manœuvres, which lasted, for I am sorry we were only present in the detached squadron, for one day; but we saw those manœuvres during the whole of that time. We are thoroughly impressed with the importance of these questions being pushed home, and being thoroughly ventilated. We unfortunately suffer to a great extent from what Captain Dawson still more forcibly put, the want of some institution or some place where these questions of a purely naval character might be discussed. Something has been said about the Harvey torpedo. Captain Colomb himself said that the Harvey torpedo had sunk in his estimation. I think it did so mainly from the fact that experiment had not been sufficiently brought to bear upon the point. I think, also, that the country is committed, to a great extent, to many rash endeavours for the same reason. Inventors seem to think that it is sufficient for an invention to be placed before the country, for the country to take it up; that such an important measure as the whole re-construction of our Navy, which was advocated the other day in the *Times*, was to follow immediately from it. The most rash schemes are put forward in that way. I may mention, having been immediately connected with some experiments with Harvey's torpedo the other day; that, in my opinion, on that particular occasion, it totally failed. We were a whole afternoon trying to ram a small ship, and did not succeed, but had to go into harbour with the torpedo unexploded at the end of it. It was not, as many gentlemen might suppose, that the error was on our side, because gunnery people had nothing to do with it; the experiment was entirely in the hands of the master of a tug, and I am sure no one would take exception to his powers of handling it. Be that as it may, still on the general question of experiments we feel that we really are powerless in the matter. I wish positively and particularly to express the craving for knowledge which exists among the junior Officers of the Navy. There is not that apathy as regards their profession which many suppose to exist. We should only be too happy to learn, but really we have no opportunity at the present day. There are experiments of every nature conducted all round. In the sister service, as Captain Dawson said, there are institutions, there are societies, and there are meetings at which all these questions are discussed. I am sorry to say that in the Navy, which ought to be our "first line of defence," we have nothing of the sort. I do not mean to say that this Institution is not very valuable in its way, but beyond this Institution I think a society ought to exist side by side with it. I do not suppose any difficulty is felt about the existence of the Institution of Royal Engineers and the Royal Artillery Institution. They are very valuable to the country. It appears to me that Captain Colomb, in his lecture has merely dealt with the general question of "fleet attacks;" I think he should not merely do that, but that he should accept the Navy as it is, and develop a system of fleet attacks with the Fleet as it is. This

point struck me the other day, viz., the extraordinary diversity of our ships. Mr. Reed specially noticed that point, and, I think, cleverly slipped out of it, because he said he could leave it to the intelligence and ingenuity of British seamen. That is the way the authorities get out of the difficulty. The powers of attack and defence possessed by the Navy of the present day are so widely diverse that it is almost impossible to study and develop the particular powers of every ship. The question of bow fire, of broadside fire, of attack by ram, and of torpedo attack, in connection with each ship, demands, as it were, a special and particular study, so that it is almost impossible to develop a system of tactics which is applicable to the Navy of the present day. In talking about this matter I have met with, I will not say extraordinary opinions, because I should be very sorry to apply such a term to the expressed opinions of Officers who are my superiors; but one Officer advocated attacking in the order of peloton, with Harvey's torpedo on each quarter. All I can say is, that I should be sorry to be in the leading vessel of the peloton, if that is to be the system of attack. I instance that, because it shows the extraordinary crudeness of opinion which exists even in high circles on these matters. I agree with Captain Dawson that after what ought to have been twenty years of definite experiment, we should have had the whole thing at our fingers' ends. I would just mention, perhaps I ought not to mention it here, that at Portsmouth, at our Naval School of Gunnery, we have endeavoured to establish a little society intended to supply these needs. We merely mean to read a few papers on professional subjects, and discuss them, and so forth. I appeal very strongly to members of my profession who may be present this evening to support such a movement, if they think it for the good of the service to do so.

Captain Robert Scott, R.N.: I will only mention one or two points in connection with what Captain Colomb has said, so as not to take up much of your time, because until we have got the results of actual experiments with different ships, there is a great deal of difficulty in deciding upon the best formation for battle. Although I concur with much that Captain Colomb has stated in his valuable paper, I cannot concur in what he says as to the small value of bow fire. I believe a powerful bow fire will be found to be very advantageous, but until we get a diagram showing the actual amount of error in aiming at the hull, and how many hits might be expected in vertical fire, and in firing down upon the upper deck of a vessel (I believe you will have a great deal of plunging fire), you cannot arrive at a just conclusion. In proportion as your guns are large, so will your shot be effective. We know that even at a very small acute angle, heavy steel shot hitting the bow would produce great effect, and if the point is arrested by the shot's biting in the armour, its base is carried forward, and the shot becomes more perpendicular to the plate as it continues to penetrate; but to effect complete penetration of thick armour you require very heavy shot. I would suggest that those who are able, and there are several Officers present to-night who are well able, should get up the subject of the powers of penetration of the different guns, together with a description of the ships, in order that all the facts may be laid before the Institution. By this means we should attain to very considerable knowledge of the value of the different ships of our Fleet, and hence be enabled to come to a much better conclusion as to the mode of using it in action than we can at the present time. As the School of Gunnery has been alluded to, I would remark that instead of being a disadvantage, it would be a very great advantage to the naval service to have a place where the younger Officers could assemble and discuss these questions. Except Captain Colomb there are as yet only one or two Officers who have taken up any of the questions relating to "naval tactics." It would be very advantageous to the profession if some Officer would lay out the models of the different ships here before us, and then show the relative amount of hits that could be anticipated both in bow fire and in broadside fire; this would enable all of us to arrive at a much more definite conclusion respecting the value of the guns than is possible with our present limited information.

Commander Pusey, R.N.: Captain Colomb has stated that the Harvey torpedo has fallen in his estimation. I should like to ask Captain Colomb, if the British Fleet were brought into action to-morrow against a Russian squadron in the Baltic, and he were Commander-in-chief, and he knew that each of the Russians opposite to him were towing a couple of torpedoes whether he would feel himself justified in taking

the British squadron into the close action that he has spoken of to-night? My impression is that if he did, and the iron-clad Fleet came to grief, the British public would stigmatise him as the murderer of our seamen. More than that, although the Harvey torpedo has been spoken of slightingly, and has been spoken of as being towed astern of vessels, yet in the experiments I have seen tried with it, the torpedoes have been on the quarter of vessels, and at right angles. I see no reason why the Harvey torpedo, by means of slip ropes, should not be towed from the bows of a ship. Many of us have been towed in a cutter from the paddle-box of a steamer, and gradually we have found ourselves abreast of the paddle-wheel. There is no reason why the Harvey torpedo should not be towed well forward. In that case I maintain that a vessel ramming, or attempting to ram, and missing her aim, would certainly come foul of the torpedo, and would thereby come to destruction. I am only a junior member of this Institution; but I offer these remarks for the consideration of those present, who, of course, will take them for what they are worth.

Captain COLOMB: I think I may generally answer the criticisms on my paper in a few words. First of all, I have restricted myself to dealing with what were so far established as facts. I have endeavoured to deal with no fictions. Those who have read my former papers on this subject will see that my opinions have very much changed, and I am quite prepared that they shall change again as soon as new facts are presented to my notice. I wish it to be understood that I take a sort of impersonal view of the question. I have been trying to collect such facts as are obtainable, and to put them together, so as to fit them into some sort of theory of attack and defence, which might set my brother Officers' minds more at work than they are at present. I have not the slightest objection, to use a nautical expression, to "Come up all I have said" about the Harvey torpedo as soon as it is different from what it now is. The state of the Harvey torpedo as it at present exists is, that if it explodes at the water line of an iron-clad ship it is held to be almost harmless. If it is charged with dynamite, or some explosive compound not yet discovered, which, on exploding at the water-line, blows the side of the ship in, the Harvey torpedo will be very different from what it is now. Then it would require less skill to manipulate. Then, as a member said, a fleet towing a number of torpedoes one on each quarter, as he describes, would be very much more dangerous than it is now. As the case at present goes, if I were suddenly promoted, as has been suggested, and were put to attack a Russian Fleet, I should, as far as I can see at present, assume the formation in line-ahead, and go at him, trusting to chance for the rest. At any rate, only one ship would be blown up the first time, to say the worst of it. I quite agree with the general expressions which have fallen from Mr. Grenfell, Captain Dawson, and Captain Scott, about the necessity for experiments. Dealing with the subject as I have dealt with it here, I can only do it most imperfectly, because there are few experiments and few facts to be got. Captain Scott upholds bow fire on grounds which are, doubtless, satisfactory to him, and he deems it much more destructive than I do. Neither of us have any facts to go by; it is simply matter of opinion. If I were dealing with the question myself, the very first thing I would do would be to go to sea to ascertain what the power of the bow-fire actually is. At present we have only some data to tell us that from a sea-going ship firing at another ship, broadside on, at a thousand yards, only about ten per cent. of the shot strike. When we know that that is the effect of shot at a fixed distance, and that ships moving, are altering the range 100 yards in 10 seconds, it seems to me, on the face of it, that without further experiments "bow fire" cannot be held effective. Of course it is hardly relevant to the paper, still we want very much indeed the circulation of even such information as is now to be got. It is most difficult to get information upon any point connected, at any rate, with subjects such as I have been dealing with to-night.

Captain WHEATLEY, R.N: Captain Colomb stated that the Harvey torpedo exploded at the water-line. I know Captain Harvey, and I know he intended his torpedo to explode some feet under water, and then it is most formidable. I think, therefore, there must have been some mismanagement if it exploded at the water-line.

The CHAIRMAN: I have no doubt that the meeting will depute me to return our most grateful thanks to Captain Colomb for his valuable paper. He has frequently come before us on questions affecting our own profession. I should very

much like to see these experiments carried out. I was delighted to hear the speech of the gallant young Officer (Lieutenant Grenfell), and to learn that the junior Officers are starting a society at Portsmouth for the discussion of professional subjects. If it were not so late I should like to have asked him whether, in the projected college at Greenwich, he thinks they will be able to carry out all these experiments in tactics and with torpedoes, which some writers in the *Times* suggest should be made in the Thames! I only hope that before it is finally determined to establish a Naval College at Greenwich, the Admiralty will duly weigh all the advantages which Officers, who have studied at Portsmouth, have found there. The college is in the dockyard, where most of the new ships can be seen from time to time, and near the "Excellent," where our gunnery instruction and experiments are carried on, and we are there among many of our brother Officers, both on shore and afloat, with whom we can discuss naval matters somewhat in the same manner as these young Officers propose to do; thus we have many means of acquiring professional knowledge, which will clearly not be available at the proposed Naval College at Greenwich.

HOLMES'S "STORM AND DANGER SIGNAL-LIGHT."

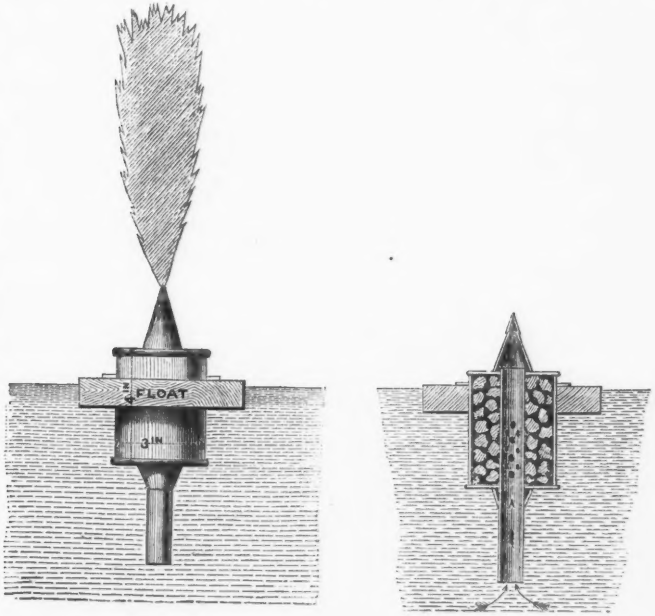
By Mr. NATHANIEL HOLMES, Electrical Engineer.

AT this late hour, I can do no more than bring before you a short explanation of a new "signal-light" which may be applied to many very useful purposes in the Navy and also in the Army. The peculiar properties of this "signal-light" are, that it is non-explosive; it is not affected by heat; you may throw it into the fire; you may melt the case, but you will not injure the composition that is inside the case. It is not affected by concussion; friction does not in away damage it. It is not affected by anything but by water. If you throw it into water it bursts into flames spontaneously, and burns with a most brilliant light for a considerable length of time. The small "signal-light" which I hold in my hand, will burn for nearly two hours; it will give a very brilliant light for forty-five minutes, and neither wind nor water will put it out. For use in connection with marine purposes I need hardly explain its many advantages. It is now adopted and in use by the Peninsular and Oriental Steam Navigation Company; by the Messageries Maritime Imperiales; and by most of the large lines of deep sea steamers. The Royal National Life Boat Association have also had some of these "storm-signals" supplied to certain of their stations for experiment. At sea it will be found invaluable. Suppose a man falls overboard, all that has to be done, is to take a knife, cut the top off the pointed end of the case, pierce a hole in the end of the bottom tube, throw the signal into the sea, when it immediately flames up and marks the spot where the man has fallen, while the boat is being lowered, and the vessel brought up in her course. If the man can swim, he swims to the light, and the boat pulls to the light; it becomes the rendezvous where to pick him up. That is one very important use of this "signal-light" at sea. By means of it, the position of a ship's boat in a dark and stormy night is accurately ascertained, and the frequent, tedious, and at times unsuccessful groping about for hours to find her, is avoided. Incidents of this kind are of frequent occurrence. Another use at sea is

where the light is placed in a small water reservoir, and used about deck as an open lanthorn for furling sails on a dark night, or for the purpose of lowering over the side of the ship in cases of fouling anchor-chains, accidents, or repairs, or at the masthead as a "flash-signal." The light at its maximum is so intense, that it may be seen for thirteen nautical miles from a ship's mast. With your permission I will now ignite one of the lights, first explaining its construction and composition; the principle of its self-ignition will then be understood.

The case is composed of a stout tin cylinder 3 inches in diameter and 4 inches high, from the lid of which a conical brass burner projects, the perforated apex of which is hermetically closed by means of a soft metal-cap soldered securely on. Through the bottom of the cylinder, a metal tube, 1 inch in diameter, passes into the interior of the case, to within $\frac{1}{8}$th inch of the upper lid, which carries the cone. The portion of the tube within the case is perforated with holes, while the tube projects outside the case $3\frac{1}{2}$ inches. The opening at the bottom of the tube is likewise hermetically sealed by a soft metal-cap. The interior of the cylinder surrounding the perforated tube is filled with the chemical ingredients.

The chemical material contained inside the "signal-light," consists of common chalk broken into small pieces about the size of bits of lump



sugar; these chalk-lumps are then heated to a white heat in a crucible containing a certain proportion of phosphorus, which being converted into vapour by the high temperature, is absorbed by the chalk when at a white heat, much as a sponge absorbs water. The chemical material thus formed (phosphate of calcium) is, when cool, placed in the signal-light-case, and the whole soldered down air-tight.

All that is required to be done, when the signal is needed for use, is with a knife to cut off the soft metal-top exposing the perforation in the brass cone for the escape of the gas, and by piercing the lower soft metal cap, to make an opening to admit water into the body of the case. On placing the signal in water, the flame immediately bursts forth, the water coming into contact with the chemical ingredient through the perforations in the inner tube. This signal-light has already been approved of by the Board of Trade for use at sea, as a substitute for blue-lights and port-fires, and some experiments have recently been made by Mr. Thomas Gray, the Secretary of the Marine Department of the Board of Trade, with a view of ascertaining how far the light could be employed in cases of shipwreck as a means of assisting the rocket-line-apparatus, by being projected in the form of a shell from the ordinary 5½-inch mortar. These experiments, suggested by Mr. T. Gray, were quite successful, the signal light being uninjured by the percussion, and blazing away on falling into the water. I place on the table the form of the light and shell to be employed for projection into the sea from the 5½-inch mortar; the two extremities of the case are of course pierced before it is fired from the mortar.

The third form of the "signal-light" on the table is, one to be used as a powerful flash and danger-signal for lifeboat services; it is contrived to produce a very powerful light for a shorter length of time; it burns for fifteen minutes or more. This modification of the signal is made, as it has been sometimes urged as an objection, that it burns too long, and cannot be extinguished. In this form there is a larger surface of the chemical material exposed to the water at the same time, more gas is therefore given off, and you obtain a brighter flame; but it burns for a shorter period.

Mr. Holmes then exhibited the mode of using the lights; two signal-lights were selected, the tops cut off, and openings made in the bottom. One was plunged under water, the other was floated on the surface, and the moment the water came in contact with the composition, a brilliant flame burst forth from each signal, and continued to burn for a long period with increasing intensity. In the case of the signal under water the flame rose to the surface, not in a continuous stream, but in a succession of gulps as it were, while the light from the signal on the surface of the water burned with the steadiness and force of a strong gas flame. The only drawback to the experiment in the room was the quantity of vapour which the lights emitted during burning. At sea this is considered an advantage, from the smoke being illuminated by the flame and seen at an immense distance.

Admiral RYDER: How long does the flatter form of signal light burn?

Mr. HOLMES: The flatter form burns about fifteen minutes with an intensely bright light. I may state that this signal light has been taken into custody twice; once at Inverness last July, when it was exhibited before the Railway Clearing House officials, and once at Brighton, when it was exhibited before the Emperor of the Brazils, the Coast Guard thinking it to be a signal for some illegal purpose.

Captain WILLES, R.N.: Does damp injure the light?

Mr. HOLMES: No, the case is perfectly air-tight, and water-tight.

Captain COLOMB, R.N.: About the storage on board ship?

Mr. HOLMES: There is no danger, and besides there is little heat in the flame; it is warm, but there is not very much heat.

Captain COLOMB: But if through damp it caught fire?

Mr. HOLMES: It cannot catch fire from damp. If it becomes damp you will perceive a disagreeable odour. Nothing but water will set it alight. Dampness will only decompose the material.

Captain WILLES: How about it if it is in a hot damp climate for six months?

Mr. HOLMES: The greater the heat, the safer the storage of the light. The damp will not affect it. Some of these lights I have kept under water three months; they are all carefully tested before they are packed, and sent out from the works.

Admiral RYDER: What is the intensity of the light as measured by gas candles?

Mr. HOLMES: It is considered to be about thirteen times the illuminating power of ordinary street gas; but I must confess to a little ignorance upon the precise relative illuminating power, for I have been so busy that I have not had time to compare it with more than the ordinary blue light at a mile and a half. This light has been burned and the blue light has been burned at the same distance. The comparison between them is remarkable. In a shipwreck, you often cannot light your blue light from damp and water, but with this signal light you are independent of the sea washing over your boat: the more water, the more light; it is inextinguishable as we have seen by water, and wind cannot put it out, though it may partially separate the continuity of the flame. With regard to the expense, I consider the expense of this light to be one-half the expense of blue lights, which are about 14*s.* a-dozen; the price of these lights is 6*s.* each; but then from one signal-light you obtain a better light, which will burn for 45 minutes, and have a light independent of water washing over it. I question whether the whole dozen blue lights would burn for 45 minutes; certainly not if they get wet. This light has been tried at Shoeburyness, under the direction of Mr. Thomas Gray, and fired out to sea, a distance of about 840 yards, from a 5½-inch mortar, with charges of 3½ and 4 ounces of powder, to see if concussion would destroy the igniting power of the light.

A VISITOR: Has the light been used as a flashing signal?

Mr. HOLMES: No, it has only at present been adopted by the Peninsular and Oriental Company, and other important lines of deep sea steamers; but I consider, when it becomes better known, that it will prove to be invaluable for certain purposes connected with Naval and Military tactics; for instance, as a signal light for the protection of torpedo lines, when flashed by a reflector across the range; for deceiving an enemy at night by false signals; for discovering what is being done under cover of darkness by an enemy's boats, by projecting these lights into their position; for protecting a shore or battery from surprise at night, by means of their illuminating power; for target practice at night; for marking the position at night of buoys, and for laying down torpedo-bearings at night; and for all other such purposes whenever a powerful light is required out of doors, simple, portable, and free from danger in transit. For military purposes it may with equal advantages be applied to pontoon-bridge building, trench work, fortification defences, camp equipments, horse picketing, and flash signals for special manœuvres, and also for balloon signals; its extreme lightness and security enabling any and every soldier to carry one or more when engaged upon special service. For shipwreck it is equally useful. Three or four thrown upon the sea will illuminate the surrounding darkness, and enable the shore rescue parties to direct their endeavours in the most practical manner. At such times the value of a brilliant inextinguishable light is beyond belief; it means the saving of many lives.

The thanks of the meeting were then voted to Mr. Holmes for exhibiting and explaining his signal-lights.

Evening Meeting.

Monday, January 22nd, 1872.

MAJOR-GENERAL F. EARDLEY-WILMOT, R.A., in the Chair.

NAMES of MEMBERS who joined the Institution between the 16th and 22nd January, 1872.

LIFE.

Wallace, Charles T., Capt. 74th Highlanders.
Poignand, George, Lieut. 59th Regiment.
Maitland, E., Capt. R.A.
Norton, Cecil W., Lieut. 5th Royal Irish Lancers.

ANNUAL.

Dobbs, F. G., Lt. 1st Middx. Art. Vols.
Crookshank, Alex. Crowder, Assist.-Controller,
Shervinton, C. R., Lt.-Colonel Unatt.
Lyons, Algernon McL., Capt. R.N.
Campbell, George, Lieut.-General, C.B., R.A.
Bushell, John M., Comdr. R.N.
Maldon, Viscount, Lieut.-Colonel Herts Yeo. Cavalry.
Price, Arthur, Paymaster, R.N.
Tufnell, Edward, Lt. 18th Royal Irish.
Clayton, Thomas, Paymaster R.N.
Mayers, J. P., Colonel late 86th Regt.
Herdman, Alfred, Lieut. 5th Royal Irish Lancers.
Mortimer, Stanley, Capt. late 60th Rifles.
Dashwood, Geo. J. E., Lieut. Scots Fus. Guards.
Blane, Gilbert Gordon, Lieut. Scots Fus. Guards.

THE EMPLOYMENT OF MITRAILLEURS DURING THE RECENT WAR, AND THEIR USE IN FUTURE WARS.

By Lieutenant-Colonel H. C. FLETCHER, Scots Fusilier Guards.

THE CHAIRMAN: Colonel Fletcher, of the Scots Fusilier Guards, who is to read a paper on the "Employment of Mitrailleurs during the recent War and their Use in future Wars," is known to most of us; and to those who do not know him, I may say that he has been long distinguished as an able and zealous Officer; and that, as a member of the Committee on the subject on which he is about to speak, he has had ample opportunities of making a thorough investigation of the merits of the mitrailleur. Whatever he says, I am sure, will receive careful consideration.

Colonel FLETCHER: In bringing before your notice the subject of the employment of the Gatling-gun in war, I wish it to be understood

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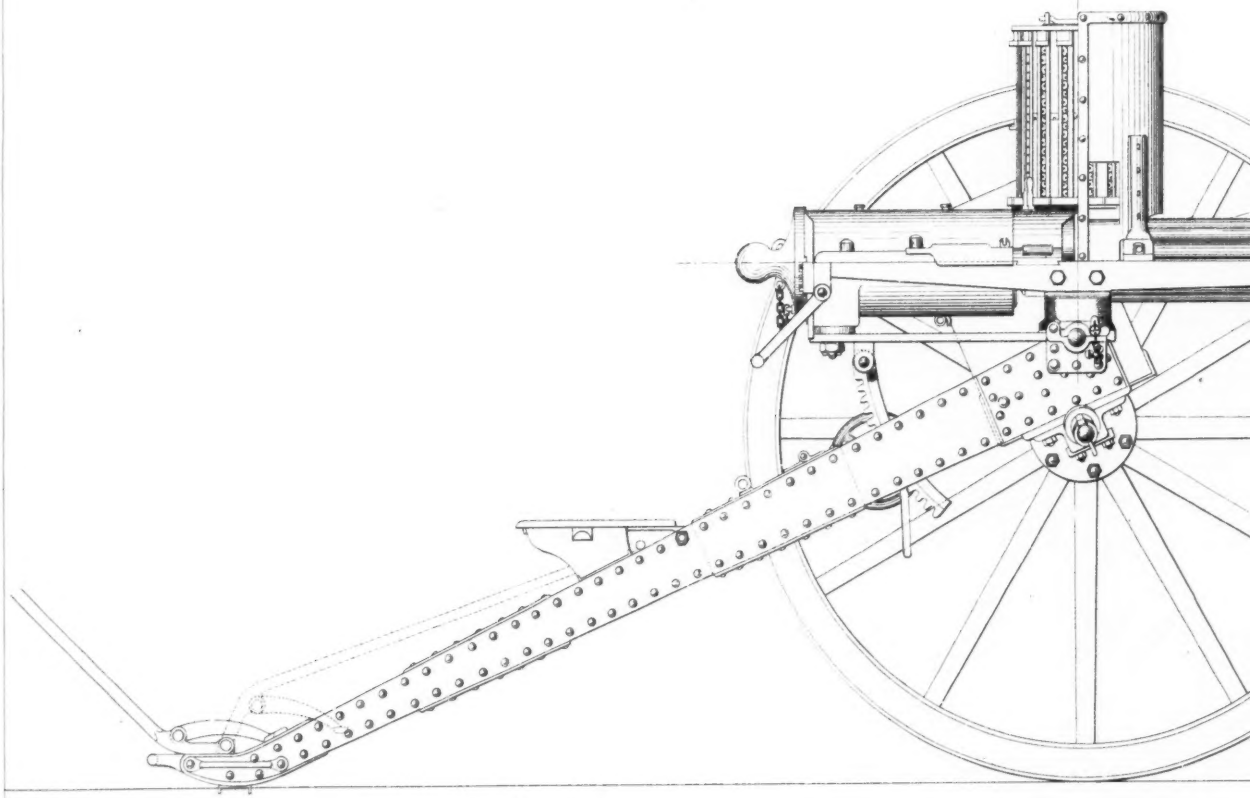
Scal

SIDE ELEVATION.

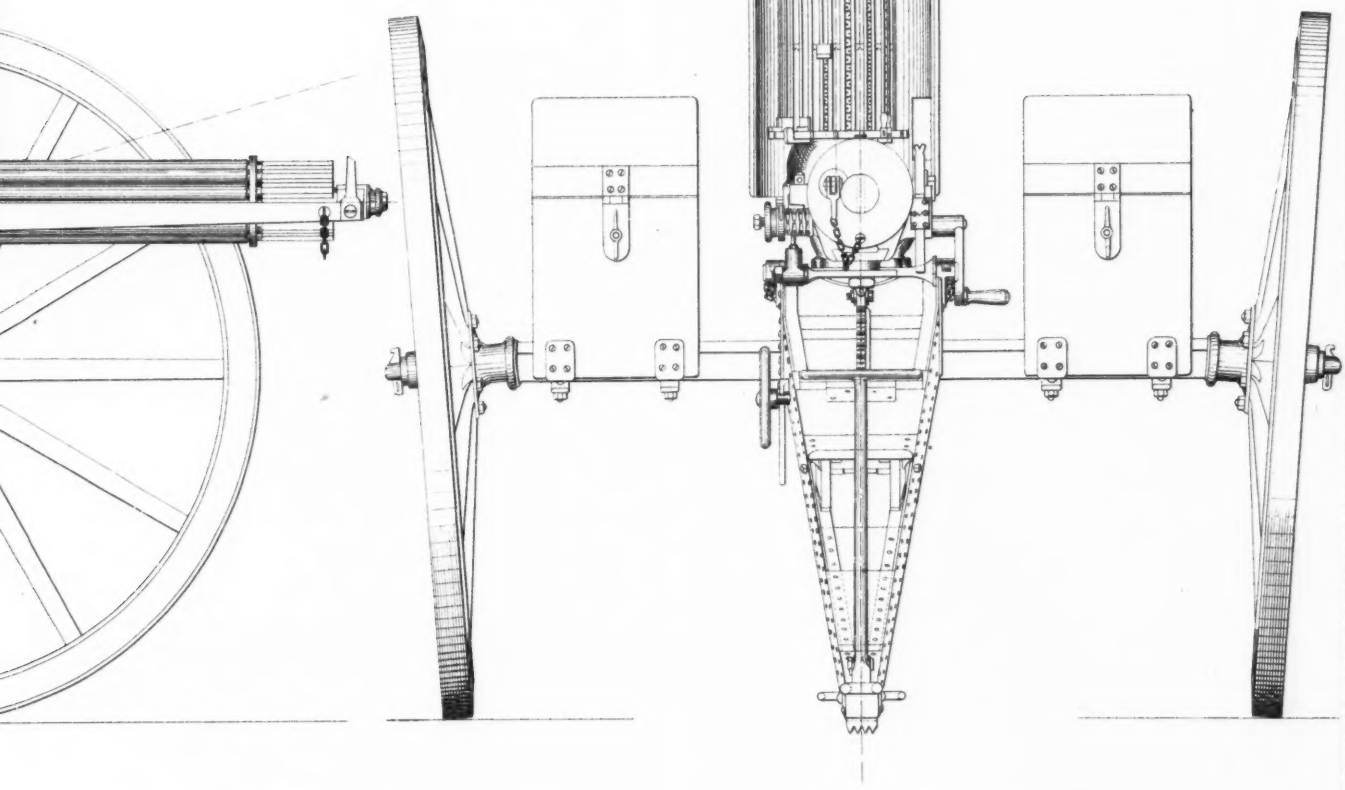


ATLING GUN & CARRIAGE.

Scale 1/12

N.

REAR ELEVATION.



J. Jobbins.

that I have little or nothing to say that is original, and have no dogmatic opinions to offer, founded either on carefully-constructed theories or on extended practice. I have merely endeavoured to collate from various documents, and especially from the reports of the War Office Committee, of which Colonel Wray is President, and of which I have the honour to be one of the members, the opinions for and against the employment of this description of weapon, and the reasons deduced from the examination of oral and written evidences for its adoption into or rejection from the category of military arms.

The mechanical construction of the gun has been already carefully described in a paper contributed to this Institution by Mr. Gatling (see vol. xiv, p. 594, *et seq.*), and not already understood, will readily be comprehended on an inspection of the drawings kindly placed at my disposal by the Secretary of State for War;* and on examination of the gun itself, also lent to the Institution for the purpose of illustrating this paper.

The subject of the employment of mitrailleurs in the wars of the future has also been very ably dealt with by Major Fosbery, V.C., in a paper communicated by him to this Institution (see vol. xiii, p. 539, *et seq.*); and the only excuse I can offer for again bringing it before the notice of the members of this Institution, lies in the fresh light that has been thrown on the merits or demerits of the mitrailleurs during the recent campaigns between France and Germany, where they were for the first time extensively used, and from the fact, regretted by Major Fosbery, that his lecture was not followed by a discussion, which would probably have elicited some valuable opinions. On these grounds I have ventured to re-open the subject, and with that view purpose to lay before you a summary of the several arguments for and against the adoption into the Services of the machine gun, embracing generally under that name, the Gatling, preferred by Colonel Wray's Committee, and the French mitrailleurs.

The idea of machine guns is not new; weapons somewhat resembling in principle the present Gatling-battery, were manufactured in the early part of the sixteenth century. They were known as "orgues" or "orgels," and the term is thus defined by M. Remi in his "Memoires de l'Artillery." "An orgue is a machine composed of several musket barrels "fastened together, and used for the defence of breeches and entrench-"ments on account of the possibility of firing from them many shots "at once." Of these "orgues" specimens still exist in Germany. They are specially mentioned by Weigel in his description of the arsenal at Nuremburg, in 1698, and are called Todtenorgels, on account of the deadly power of the thirty-three barrels of which each were composed.†

* The Institution is indebted to Sir William Armstrong and Co. for the accompanying plate of the .45 Gatling-gun with the latest additions and improvements. —Ed.

† Since writing this paper, the author's attention has been called by Captain H. Brackenbury, R.A., to the employment of weapons somewhat resembling in principle the mitrailleur as early as the year 1382. They were termed ribandeause or ribauldequins, and were used by the men of Ghent in their attack on Bruges.

Probably, as was the case with the revolvers of that early period, defects in manufacturing skill prevented their perfection; whilst, although some of them appear to have been loaded at the breech, no attempt was made to secure continuity of fire, such as is possessed by the modern Gatling-gun. In another and most important respect, the old machine guns were defective. The method of inserting the charge in rigid cartridge cases was unknown. and, as Major Fosbery points out, the serviceability of this description of weapon has mainly resulted from the adoption of the metal cartridge-case of comparatively recent invention.

It is not, however, with the history of mitrailleurs that I propose to deal; allusion to it was necessary, first, to show that these arms were known to our forefathers, and were by them recognized as serviceable for certain military purposes; and, secondly, to meet the objection which might be raised against them, that they have never played a prominent part in former wars, by pointing out that although the principle might have been recognized, its application was defective.

The real point at issue is, whether the best form of machine gun, which, assuming the Report of Colonel Wray's Committee to be correct, is that known as the "Gatling," is a weapon which ought to find its place in modern warfare. That it possesses fearfully destructive powers, no one who has ever seen it fired, can doubt; but whether it should, in accordance with its greatest admirers, take the place of the lighter artillery, whether it should supplement that arm, as some who are more moderate would recommend, or whether it should be cast aside as a curious but comparatively unserviceable weapon, as others would urge, are the questions that I would desire to present to you for discussion this evening.

In order to form just conclusions on this important subject, a knowledge of the grounds on which the admirers and opponents of the mitrailleurs (to use the term as embracing the principle) found their opinions, is essential; and, therefore, I propose to endeavour, first, to place before you in a few words the alleged reasons for and against their extensive introduction into the Services, and then to try to prove how far these reasons have been justified by the experiences of the late war.

To commence with the opinions of those most in favour of the arm, Major Fosbery in his paper (before alluded to) when advocating the adoption into our Services of the Montigny mitrailleurs, sums up their advantages and disadvantages in comparison with field artillery. He commences his argument by laying down the broad principle, that in war as in peace, machinery should, as far as practicable, take the place of human labour. "If," he says, "it be possible, by means of a "machine, not too liable to derangement, and not too complicated "for the comprehension of the soldier, to make three or four men do "the work of 120, the advantage must be self-evident." Granting this hypothesis, it remains to be shown whether the result claimed has not already been attained by artillery, and whether, if guns are still further to replace men, an increase in field artillery would not fulfil the desired object.

Major Fosbery considers that room exists for the employment of an intermediate weapon between infantry and artillery, and infers that at the shorter ranges, the mitrailleurs will be a more certain, and, consequently, more effective arm than field guns. He instances the experiments made before the *Segment and Shrapnel Shell Committee* in 1869, where, to judge from the report, the results of artillery fire against infantry — but feebly entrenched — was remarkably slight, and where the numerous faulty rounds, consequent generally on defective fuzes, showed that there are in artillery fire important elements of error, irrespective of inaccuracies of aim. Greater rapidity of fire is claimed for the mitrailleur as compared with the field gun, measuring that rapidity by the number of shots compared with the number of pieces of segment, or bullets in shrapnel; and if at the longer ranges, say at 1,400 or 2,000 yards, the advantage lies with the field gun, at ranges under 1,200 yards the conditions are, by Major Fosbery, believed to be reversed. The mitrailleur if exposed to artillery fire at the longer distance, would, consequently, probably be knocked over, whilst if approached by that arm within its effective range, it would inflict serious injury on the horses and gun detachments.

Mr. Gatling, in the paper before referred to, presses the utility of his invention to a point beyond Major Fosbery. He advocates powerful long range Gatlings to compete with field artillery, and thus sums up their advantages:—

1. Equal range, and greater accuracy and precision than field-guns.
2. Rapidity and continuity of fire, viz., 200 shots per minute, each bullet weighing a half pound.
3. No re-sighting or relaying between each discharge, there being little or no recoil.
4. Lightness.
5. Greater power of ricochet fire.
6. Economy in money, in horses, and in men.

In his pamphlet Mr. Gatling still further urges the claims of his gun in comparison with infantry. He considers it as the means of revolutionizing in a great degree the present modes of warfare. A few men furnished with these death-dealing engines will, according to his opinion, be able to defeat thousands armed with ordinary weapons; consequently their use will, in a great degree, supersede the necessity for large armies.

He considers the accuracy of the Gatling fire will, shot for shot, be much greater than that of the infantry, on account of its greater steadiness, and its want of nerves, whilst the exposure of life, owing to the small number of men necessary for the service of the gun, will be comparatively very slight.

Having thus briefly alluded to the opinions ably set forth by Major Fosbery and Mr. Gatling, I propose to detail the reasons, founded on experiment, which induced Colonel Wray's Committee to reject for land-service, the larger Gatling-gun, and to recommend the smaller arm, throwing a bullet of similar size to that of the new army rifle.

In their report of the 28th October, 1870, the Committee point out the difference of opinion which existed as to the value of these arms in Prussia and in France, the former being adverse to them on the ground that the narrow sphere within which their effect was restricted did not compensate for the *personnel* and *matériel* required in serving them, whilst the latter, taking a different view, adopted the mitrailleurs in comparatively large numbers. The Committee then justify their preference for the Gatling over the Montigny, and having selected the former, state what they consider to be their uses in warfare. As this part of the report summarizes generally the opinion of those who hold a moderate view on this disputed question, I think it well to read it *in extenso*:—

Extract from the Report of Colonel Wray's Committee.

"The results of the recent enquiry have fully satisfied the Committee of the expediency of introducing a certain proportion of these machine guns, to act as auxiliaries to the other arms of the service; and, of the several designs which have been submitted for their consideration, including those that have been under trial, they are persuaded that the Gatling-gun is the best adapted to meet all military requirements.

"To assist in defending such positions as villages, field entrenchments, &c., the Committee feel satisfied that the small Gatling would be found invaluable.

"For the defence of caponnières, for covering the approach to bridges or *têtes-de-pont*, for defending a breach, and for employment in advanced trenches or in field works, where economy of space is of the utmost importance, the same sized Gatling would unquestionably be a most effective weapon.

"For naval purposes, the small Gatling would apparently be well adapted for use in the tops of vessels-of-war, to clear the enemy's decks, or open ports; while for gun-boats that carry only one heavy gun, and for boat operations, the medium sized Gatling would be most effective in covering the landing of troops, or for service up close rivers.

"The Committee are also impressed with the effect produced by the medium sized Gatling, 0·65 inch calibre, at long ranges as compared with that of a field gun, but looking to the weight of ammunition required to produce this effect, and to the exceptional conditions under which the larger Gatling could be used with advantage in the field, they are satisfied that a gun is far preferable at long ranges, and, consequently, they do not recommend the introduction of the larger description of Gatling for land service.

"In advocating the introduction of the small Gatling-gun, the Committee wish it to be distinctly understood that they do not for a moment contemplate their supplanting or displacing a single field gun, the proportions of which have been laid down by the best military authorities, as indispensable for an army in the field.

"The characteristics of the two weapons are essentially different.

"Except against an enemy in the open, the fire of a mitrailleur is comparatively worthless, whereas artillery fire will search out an enemy from almost any position, whether covered by trees, brushwood, earthworks, or houses, and at distances far beyond the range of a mitrailleur; but, in the open, and at distances up to 1,200 yards, there is reason to believe that the latter will be found the more destructive, owing to the rapidity and continuity of its fire."

This report resulted from an examination of the trials which were from time to time conducted in the year 1870 between the Gatling and the Montigny, and between these mitrailleurs as compared with infantry and artillery. The Committee which submitted it was composed of Colonel Wray, an Artillery Officer, as President; an Officer of the Royal Navy; one from the Royal Engineers; three Artillery and one Infantry Officer. Thus, although preponderating in numbers, the artillery element was counterbalanced by representatives from other branches of the professions. The experiments clearly showed the deadly effect of the fire of the smaller Gatling at ranges up to 1,400 yards, whilst the larger and medium guns gave good results at ranges up to 2,070 yards.

From a comparison of a series of eleven trials of the small size Gatling, of the 9-pounder muzzle-loading field gun firing shrapnel, and of the Martini-Henry rifle fired by six guardsmen, at ranges from 300 to 1,200 yards, and under various conditions in regard to time and known and unknown distances, I find that the Gatling made 2,699 hits, the 9-pounder muzzle-loader 1,620 hits, and the Martini-Henry 718 hits, *i.e.*, the Gatling was about $3\frac{3}{5}$ times and the 9-pounder $2\frac{1}{4}$ times more effective than the Martini-Henry in the hands of six soldiers, a result I would venture to term satisfactory as regards infantry fire. Not that I mean to affirm that this comparison is a true measure of the efficiency of the 9-pounder and Gatling as compared with infantry. To say that the fire from a field gun was only equal to that of fourteen infantry, and that that of a Gatling was not more deadly than the fire of twenty-two infantry, and to measure their efficiency in the field by this standard, would lead to very erroneous conclusions. Each arm I contend has its own duty to perform, and there are moments in battles when no field gun or Gatling would counterbalance the absence of even a section of infantry, as there are times when a single shell from a 9-pounder, or a volley from a Gatling, would be worth more than the presence of a battalion.

Notwithstanding these trials, the opponents of the mitrailleur, whilst admitting its exceptionably deadly fire, maintained that its introduction into modern armaments was a retrograde step. They alleged that only a certain proportion of guns, laid down broadly as $2\frac{3}{4}$ per 1,000 infantry and cavalry, could accompany an army in the field. That an increase in the number would unduly augment the "impedimenta," would block up the line of march, and would probably be found impracticable to manage in action. Consequently, as it would be undesirable (taking the views of the Committee) to diminish the field artillery, the addition to this arm of mitrailleur-batteries would unduly add to the wheeled transport, and prove an incumbrance to an army from the increase in the number of horses

which would require feeding. Supposing modern warfare should permit of an addition to the number of wheeled armaments, the opponents of the mitrailleur consider that the artillery should be increased rather than be supplemented by machine-guns, as, although in experimental practice at the shorter ranges, the Gatlings have proved more deadly than any description of shot or shell when fired against representation of troops in the open, yet that the field-gun has by far the longer range, and has greater scope in its powers, being useful against entrenchments as well as against men. They affirm that field guns will be able to destroy the mitrailleurs whenever they venture to show themselves, and that no hail of rifle bullets can equal in moral effect the fire of shell from artillery. They also say that the range of the field-guns can be more easily tested by trial shots than the range of the Gatling.

Such, given shortly, are the opinions of those who oppose the introduction of the mitrailleurs into the military service.

Its modified acceptance by the Navy does not appear to have provoked so much opposition. The report of the Naval Committee assembled, in 1868, at Washington, confirms the opinion expressed by Colonel Wray's Committee, of which Captain Foley, R.N., was one of the members. The Report, as quoted by Mr. Gatling, states as follows:—"The American Naval Officers consider it serviceable "as an auxiliary arm for special service, to be used from top-gallant "forecastle, poop decks, and tops of vessels of war, and in boat opera- "tions against an enemy, either in passing open land works or clearing "breaches and other proposed places for landing from boats, &c. If "opposing infantry and cavalry it has no known superior, its great "merit consists in its accuracy within the limits of its range; the cer- "tainty, and if need be, rapidity of fire, with the additional merit of "only requiring three persons to load, direct, and fire each piece, when "suitably mounted, afloat or ashore." It has also been suggested that the Gatling will be found useful in firing into the ports of vessels of war attempting to pass forts, which owing to the narrowness of the channel, they may be forced to approach within close range.

Whatever opinions may have been held on these weapons, their practical employment in war should be the true test by which to judge of their efficiency, provided that the arms themselves are good and their proper use understood. Until the recent campaign in France, no opportunity occurred of testing their presumed merits. "Machine-guns," somewhat resembling the Gatling, were indeed exhibited to General M'Clellan during his campaign before Richmond, in 1862; they were called somewhat contemptuously coffee-grinders, and were not brought to the front. The army already possessed an undue proportion of artillery, and the wooded country in which its battles were fought, was not favourable to the use of this description of gun, supposing its mechanism to have been sufficiently perfected. Consequently the "machine-guns" remained untested, and were not subsequently brought into use during the later campaigns of the American war;* neither were they employed during either the Danish or Prusso-

* A weapon with twenty-five barrels, resembling the mitrailleur, was employed, in 1863, in the attack on Fort Wagner.

Austrian wars, and it remained for the French War Department to ensure to them their first practical trial.

Partly from a belief in their merits, partly to raise the *morale* of the troops, and to counterbalance the prestige of the Prussian Army, fresh from its victories over Austria, the French military authorities unduly exalted the advantages of the mysterious engine hidden in their arsenals. Terrible stories of its destructive powers were allowed to leak out, and every method was taken to rouse the confidence of the troops in the new weapon which was to revolutionize war. On the 1st of July, 1870, the Army was provided with 190 mitrailleurs.

At the first skirmish, viz., the affair before Saarbruck, the mitrailleur was brought to the front and shared with the Prince Imperial the honours of this short-lived success. The events that followed were so awful, and the defeats of the French Army succeeded each other so rapidly, that opportunity did not offer of examining critically the employment of any particular arm. Now and then, among the many accounts of these battles, anecdotes of the mitrailleurs are narrated, sometimes mentioning them derisively, at others alluding to the deadly effects of their fire, and summing up with the enumeration of the numbers captured at the successive surrender of the French armies.

Feeling the importance of investigating the truth of the many statements which were put forth on this important question, Colonel Wray's Committee decided on taking evidence from Officers who had been witnesses of some of the engagements, although unfortunately, owing to the veto put upon the presence of English Officers with either army during the earlier campaigns, little direct information as to the employment of the mitrailleurs previous to the battle of Sedan, could be obtained. The evidence, therefore, relates principally to the later actions fought on the Loire. Time will admit of but a short summary of what was given before the Committee, but should anyone desire still further to investigate the subject, he has only to read the evidence in full. The effect of the French mitrailleurs (for, excepting in one Bavarian corps, none were brought into the field by the Germans) was witnessed by several of our Officers on different occasions, and has been alluded to by more than one writer on the war.

Thus Colonel Rüstow speaks of a mitrailleuse battery of Douay's division being in action for a short time at the battle of Weissenberg, when its ammunition waggon was struck by a Prussian shell and blown up, wounding so many of the gunners that it was forced to withdraw, not, however (if one may judge from the accounts of those who have inspected the field of battle), before it had inflicted heavy loss on the advancing infantry.

In a book entitled "From Sedan to Saarbruck," by an Artillery Officer, the effect of the fire of six mitrailleurs at the battle before Sedan is thus narrated. The guns were entrenched, and played with deadly effect on the Prussians who attempted to cross a valley intervening between them and some rising ground about 900 yards distant. The author writes, "that the numerous Prussian graves on the slope "of the Mamelon attest the severe loss they suffered, and," he adds, "in this solitary instance the effects of the mitrailleurs were con-

" fessedly superior to any which could have been inflicted by common " shell." He further quotes the opinion of a Prussian Officer given to him personally, which appears to be in accordance with that of the generality of the German Officers during the War. This Officer admitted that the effect of the mitrailleur against solid masses was good; but he considered them comparatively harmless against troops in line, under which circumstances their action might be likened to a charge of unscattered swan shot, merely riddling two or three men. It is fair to say that this defect in the French mitrailleur has been remedied in the Gatling, in which the traversing arrangement permits of a wide sweep of the shots during the very process of firing.

Mr. Winn thus describes the effect of the mitrailleurs on a body of cavalry at the battle of Gravelotte:—" It was about 3 o'clock that " Malmaison was taken by our (meaning the German) troops, and " it was on some Uhlans, who tried to cut off the retreat of some Vol- " tiguers from it, that the mitrailleur so terribly vindicated its " character for destruction. A squadron rode forward with its usual " pride and confidence; we heard the growl of this truly infernal " machine; we saw an unwonted confusion in the Lancers' ranks; they " wheeled, and retired, leaving behind them 32 horses and as many " men. They had unwittingly crossed the fatal line of fire; and had " they waited to rescue their comrades, three minutes would have " sufficed to the French artillerymen to put them in the same helpless " condition. We had gone forward to the extreme point on our side " of the glen, and with our glasses could plainly see the gunners as " they placed the fatal plate in the hydra-mouthed cannon."

Colonel Fielding attached great value to the mitrailleur, and instanced the effects produced on a Prussian column of infantry at the second battle of Beaugency, where clear gaps were cut through one of its angles. The same effect, he thinks, could not have been produced by infantry, as the time necessarily spent in deployment would have given warning to the approaching column. " He looked upon " the proper use of mitrailleurs to be as representing a certain number " of infantry, for which there is not room on the ground, suddenly " placed forward at the proper moment, at a decisive point, to bring a " crushing fire upon the enemy." He also prefers placing them in defensive positions " where the front is restricted, and where it is neces- " sary while keeping up a proper amount of fire to the front, to econo- " mise space."

On three different occasions Colonel Reilly, C.B., R.A., saw the mitrailleurs used against troops who were taking advantage of the undulations of the ground to obtain cover, and on none of these occasions did he notice the loss inflicted by them to have been great. On the other hand, although the mitrailleurs were standing in the open, exposed to the fire of the Prussian artillery for four and a half hours, no injury was done to them by shot or shell. At Beaume le Rolande, the French did good service in street fighting with the mitrailleurs, but on the whole, Colonel Reilly evidently considered that artillery would have been more efficient, and that the extra wheeled transport entailed

by this description of armament, did more harm than good to the French Armies. He also states that the Prussian Officers were greatly opposed to incumbering infantry regiments with mitrailleurs, even supposing they were introduced into their service.

Captain C. B. Brackenbury, R.A., who was present with the Army of Prince Frederick Charles, narrates that upon the only occasions when he witnessed any serious effect from the mitrailleurs, three of them succeeded in stopping the advance of the German troops who had hitherto faced the fire of the artillery. These three mitrailleurs were subsequently captured by skirmishers detached from the main body, who took them in flank. He considers their fire to be superior to that of infantry, because an infantry man has nerves, which will probably be disturbed when he is exposed to fire, whereas the machine has none.

Captain Hozier formed opinions similar to those of Captain Brackenbury. He saw mitrailleurs employed in the sorties from Paris, and at Le Mans, where the supports of a line of skirmishers suffered from their fire; the skirmishers, however, advancing beneath them, and avoiding their direct discharge, closed in, and captured them. By this method the mitrailleur batteries were usually taken, their infantry supports retiring and leaving the guns to their fate. On the whole, Captain Hozier concurs in the opinion of the Prussian Officers with whom he conversed, that for field service the horses and men necessary for the mitrailleurs could be better employed with artillery, but that for entrenched positions, for narrow roads, and for the ditches of fortresses they were and would be most valuable. Prince Frederick Charles expressed a preference for twelve or thirteen infantry soldiers instead of a mitrailleur, as they would be less liable to be destroyed by a bursting shell, and their fire would be more accurate.

Captain Gurdon, R.N., who witnessed the later campaigns on the French side, entertains a high opinion of the efficiency of the mitrailleur fire. He saw them employed against infantry columns, and on one occasion against field batteries, which were compelled to retire, owing to a loss of horses. He considers them quite indispensable in warfare at the present day, but does not agree with the French in their method of employing them. They are adapted, he believes, for defence rather than for attack, and are especially suited for protecting gorges or defiles, and for street fighting. The French mitrailleurs he considers to have been too heavy, as four horses were required for the gun alone. The weight of the guns, or rather their increased charges, seem to have given range, as, according to Captain Gurdon, they were most efficient at from 1,800 to 2,300 yards.

Captain Henry Brackenbury corroborates much that was said by Captain Gurdon, but reduces the effective range of the mitrailleur to about 1,000 yards, possibly alluding to a weapon of less calibre. He had the advantage of noticing their destructive powers when well placed, and their inefficiency in the hands of those who were ignorant of their proper use. The description he gives of the battle of Sedan presents so vivid a picture of mitrailleurs when well handled, that I hope I shall be excused if I quote it from his evidence. "Two or

"three days after the battle of Sedan, I was (he says) on the field: "they had not long finished burying the dead. I was very much "struck with the number of graves at one point, just between Douzy "and Bazeilles. I made enquiries, and was told that great havoc had "been committed there by some French mitrailleurs. It was pointed "out to me where the battery of mitrailleurs had been in action, and I "went there and found that evidently a battery had been in action, and "for a considerable period, because there was a great number of empty "mitrailleur boxes lying about. I noticed in the first place that the "position they had taken up was one that appeared to be splendid for "the use of the mitrailleur. It was just on the crest of very slightly "undulating ground in a perfectly open field: they had a sort of "glacis in front of them, extending down perhaps 800 or 900 yards "and a gentle hill opposite, extending for 600 or 700 more. The crest "of the opposite hill, the rise all being slight, was about 1,300 or "1,400 yards off. It was at this distance that they had done great "execution." Subsequently he witnessed the employment of the mitrailleurs by the insurgents at Paris, who fired from the forts of Issy and Vanves at a range of 1,650 yards, with very little effect. Captain Brackenbury concurs generally with the other evidence that mitrailleurs are suited for purposes of defence, and although he does not consider that an army provided with these weapons, holds any very great advantage over its opponent who relies on field artillery, yet he believes them to be a valuable adjunct to that arm, and instances as a proof that the French Marshal commanding the 6th Corps regretted their absence from the right of the position at Gravelotte, and that the Prussian Officers looked on them with marked respect, and when called to face them, with decided aversion.

Mr. Charles Coffey witnessed the employment of mitrailleurs with great effect against a line of advancing Prussians at the action at Sillé le Guillaume, and coincides with the opinion of the French Artillery Officers with whom he spoke, that they were very valuable in war.

Major-General Walker, C.B., who was present with the German armies during the campaign, evidently agrees with the Prussian Staff in his opinion on the merits or rather demerits of the mitrailleurs. He sees no place for them in European warfare, as he believes them to be inferior to artillery, especially when good shrapnel shells are employed. He acknowledges their possible value against undisciplined troops badly provided with artillery, and in purely defensive positions, where the opponent is forced to advance on a fixed and narrow front, but deprecates any diminution in their favour of field artillery, and does not think that it is desirable to encumber infantry movements by attaching them to that branch of the service.

Colonel Hamley, R.A., who critically examined the evidence for and against the mitrailleur, condemns them absolutely for offensive operations, where, as must almost always be the case, the attack is to be preceded by a concentrated fire of artillery. Even for defensive purposes, in an open country, he considers that the effect, owing to their shorter range, would be less than that of artillery, but on the other hand, in certain positions where the area of attack is limited to 1,200

yards, and when the enemy is approaching on a narrow front, they might be most usefully employed.

On the German side, there is but one solitary instance of the employment of the revolving cannon, a description of mitrailleur, placed under the command of Captain Count Thürheim, and attached to the Bavarian corps of Von der Tann. The mechanism of these guns appears to have been defective, and Count Thürheim, after experience of their power, restricts their employment solely to defensive purposes in entrenched positions.

In giving this summary of the evidence taken by Colonel Wray's Committee, I must guard myself from the accusation of endeavouring to force conclusions by quoting only so much as would prove a case for or against the mitrailleur. I have endeavoured fairly to convey the impression produced by the several witnesses; but I would recommend all who are interested in the subject, carefully to study the evidence for themselves, as it is almost impossible by selecting particular passages, to convey a perfectly correct impression of the whole.

The deductions from its perusal appear to be as follows: 1. That the French Officers and those who have witnessed the campaign from the French side, are generally in favour of the employment of mitrailleurs in the field. 2. That the Prussian Staff disapprove of their introduction into the army, except for the very limited service of the defence of the ditches of fortresses. 3. That the English Officers, who were present with the German Armies, are with one exception of opinion that for certain purposes they may be useful adjuncts to field artillery. 4. Almost all who advocate their use, consider that they should form part of the artillery of an army, that they should supplement that arm, and that their place lies in defensive rather than in offensive tactics. 5. That their proper employment had not, possibly from want of opportunity, been carefully studied by French Officers previous to the war, and consequently that they were frequently unprofitably used. 6. That although the mitrailleur or Gatling (for both were employed by the French) of larger calibre was superior in range to the lighter arm, yet that owing to its increased weight, the horses necessary for its transport would nearly equal in number those of a field gun, and consequently that its advantages being more than counterbalanced by this drawback, a field gun would be preferred.

Second Report of Colonel Wray's Committee.

After duly weighing the evidence—of which I have endeavoured to give a summary—Colonel Wray's Committee drew up a second Report, on the 21st November, 1871, in which they laid down distinctly, that the mitrailleurs should be treated purely as defensive weapons, and that they should in general be entrenched and kept, as far as possible, masked from artillery fire. That the so-called small Gatling of ·45 calibre, of which the destructive effect against troops in the open at ranges up to 1,400 yards, is estimated as being nearly three times that of the 9-pounder field gun, should be so lightened as to be easily drawn with its carriage and ammunition by two horses, and, on emergency,

by one. That the field artillery should not be reduced by a single man or horse for the sake of substituting mitrailleurs; but that these latter should be kept with the reserves of an Army in the field for the express purpose of increasing infantry fire at critical moments, in the same way that guns of position are used for strengthening the fire of field artillery. That the mitrailleur batteries should be provided with Nolan's range-finders.

With reference to the difference in opinion on these subjects between the German and French Officers, the Committee offer the following remarks, which I would recommend for your consideration:—"1. That "the Gatling gun was very little used by the French. 2. That the "French mitrailleur was almost as heavy, and required as many "men and horses as the field gun. 3. That the French appear, by "all accounts, to have used their mitrailleurs with little judgment, "firing them into all sorts of cover, at very long ranges, and without "any special means of ascertaining the distances. They seem also to "have frequently neglected the precaution of covering their mitrail-"leurs, either naturally or artificially, thus laying them open to de-"struction by the German artillery. 4. That the Germans had no "opportunity of testing the merits of mitrailleurs for defensive pur-"poses, having almost invariably acted on the offensive. 5 (and I "would draw especial attention to this remark). That the Germans "have no necessity for considering the question of introducing these "weapons, being already well provided with a very large number of "French mitrailleurs, which, having recently been tried at Berlin in "comparison with Montigny and Gatling mitrailleurs, have been unani-"mously pronounced superior to either," an opinion, I would observe, in which the Committee did not agree. I would also add, that as during the war, the Germans were unprovided with an effective mitrailleur, and as the destructive effects of the fire of the French weapon had been bruited abroad with the object of elevating the *morale* of their own troops and depressing that of the enemy, it became almost necessary for the Prussian staff to decry its powers, and disabuse the minds of the soldiers of an exaggerated fear of its effects.

Most, if not all, the great Powers of Europe have provisionally adopted some description of mitrailleur. The French retain those they employed during the war. The Prussians possess large numbers, which were captured from the enemy. The Austrians are manufacturing machine guns, on Messrs. Paget and Broadwell's principle, and are attaching them to the regiments of Hungarian militia. The Russians are making large numbers of Gatlings, on (I believe) Colonel Gorloff's principle, and it is said that 400 or 500 guns are ready, or are nearly completed. The rapidity of fire is stated to have been increased up to the almost incredible number of 1,000 shots per minute, which rapidity can, however, be regulated and checked by a simple adjustment of the feeding apparatus. The gun has been lightened, and the spreading motion of its fire improved. The Turks have ordered a large supply similar in pattern to that selected by Austria. With regard to America, although it appears that there has been no formal adoption of the mitrailleur, their utility has been reported favourably on by

American Officers, and the manufactory with which Mr. Gatling is connected, has every means of turning them out rapidly in the event of war. They are employed in arming the forts in the Far West against the attack of Indians; and (as I have been to-day informed by Captain Selwyn, R.N.) a certain number are in readiness at Salt Lake City, in the event of any trouble with the Mormons.

At present no Government has given orders respecting their tactical employment, and it is on this point that I would venture to direct your opinion, trusting that a discussion by able Officers of all branches of the two services, may tend to elucidate a question which at present presents many complications, and is attended with considerable difficulty.

Comparisons in the Equipment of 9-pounder Field Gun and Gatling Batteries.

In order to assist in forming conclusions, I am enabled to offer an estimate, prepared by Colonel Wray, of the comparative number of horses, men, and waggons, which are required for a battery of six 9-pounder field guns, and for a battery of twelve Gatlings.

Comparative Equipment of a 9-pounder Field Battery of 6 guns, and of a Battery of 12 Gatling Guns.

9-Pounder Field Battery. 6 Guns.	*Gatling Battery. 12 Guns, ·45 calibre.*
1 Captain.	1 Captain.
1 Second Captain.	1 Second Captain.
3 Lieutenants.	3 Lieutenants.
1 Assistant-surgeon.	1 Assistant-surgeon.
6	6
1 Serjeant-major.	1 Serjeant-major.
1 Quartermaster-serjeant.	1 Quartermaster-serjeant.
6 Serjeants.	6 Serjeants.
6 Corporals.	6 Corporals.
6 Bombardiers.	60 Gunners.
85 Gunners.	20 Drivers.
81 Drivers.	2 Trumpeters.
2 Trumpeters.	1 Farrier.
1 Farrier.	2 Shoeing smiths.
4 Shoeing smiths.	1 Collar maker.
2 Collar makers.	1 Wheeler.
2 Wheelers.	
197	101

6 Guns.
12 Waggons.
1 Store waggon.
1 Forge waggon.
1 General Service waggon.
1 Store cart.
214 Rounds per gun.

Riding Horses.
12 Officers'.
2 Staff Serjeants'.
12 Non-commissioned Officers'.
2 Trumpeters'.
1 Farrier's.
1 Shoeing smith's.
4 Spare.

34

Draught Horses.
48 Guns.
72 Ammunition waggons.
6 Store waggon.
6 Forge.
4 General Service.
2 Store cart.
12 Spare.

150

184 Total horses

12 Gatling guns.
6 Small arm ammunition carts.
1 Store waggon.
1 } Forge and General Service waggon combined.

2,208 Cartridges carried with each gun 26,496
9,000 Cartridges in each S.A.A. cart 54,000

12)80,496

Cartridges per gun 6,708

Riding Horses.
12 Officers'.
2 Staff-serjeants'.
12 Non-commissioned Officers'.
2 Trumpeters'.
1 Farrier's.
1 Shoeing smith's.
4 Spare.

34

Draught Horses.
24 Guns.
12 Small arm ammunition cart.
6 Store waggon.
6 { Forge and General Service waggon combined.

8 Spare.

56

90 Total horses.

The total weight of draught of the Gatling is as follows:—

	cwts.	qrs.	lbs.
Gun carriage when complete	7	0	7½
Limber ditto	5	0	25
Six drums filled	3	2	0
Total	15	3	4½

Supposing a shield to be introduced for protection against the fire of infantry, an advantage which I scarcely think counterbalances the additional incumbrance, 3 qrs. 25 lbs. would require to be added to this weight, making a total of 16 cwt. 3 qrs. 1½ lbs.

There is another important question bearing on this portion of the subject which should be considered, especially as the opponents of the Gatling gun found their chief objection to its supplementing artillery, on the increased "impedimenta" thereby arising on the line of march. That a battery of twelve Gatlings must cover a considerable length of road is of course a fact that cannot be controverted, but comparing the space occupied with that covered by a battery of six 9-pounders, the

advantage will tell considerably in favour of the Gatling, as is shown by the following table, also prepared by Colonel Wray :—

Space occupied by a battery of six 9-pounder field guns, as compared with that occupied by a battery of 12 Gatlings :—

9-Pounder Battery.

	Length in yards.	Total.
6 guns, 8 horses	19	114
12 waggons, 6 horses	15	180
1 store waggon, 6 horses	15	15
1 forge, 6 horses	15	15
1 General Service waggon, 4 horses	11	11
1 store cart, 2 horses	8	8
Total in yards		353

Battery of 12 Gatlings.

	Yards.	Total.
12 guns, 2 horses	7	84
6 carts, 2 horses	7	42
1 store waggon, 6 horses	15	15
1 General Service waggon and forge combined, 6 horses	15	15
Total in yards		156

Should it be required to divide the battery, either on the march, or when about to come into action, the two captains would each take a half battery of 6 guns, or if subdivided, the three subalterns would command divisions of 4 guns, in place of 2, as in a field battery.

If you accept these calculations as correct, you will, doubtless, in the comparison between the Gatling and field artillery, give due weight to the comparatively small number of men and horses required for the former, as opposed to those necessary for the service of a battery of field artillery, and will balance these advantages against the greater power and range of the field guns. There can, also, be little doubt but that Gatlings will, from their lightness, be able to move over ground impassible for artillery, and that, although their range may be less, their effect at distances under 1,200 yards will certainly be found to be more deadly.

In the Duke of Wurtemberg's pamphlet, it is stated that the Prussian artillery usually open fire at distances varying from 1,400 to 1,600 paces, whilst Colonel Reilly corroborates this statement in his evidence given before Colonel Wray's Committee, by saying that at an action at which he was present near Orleans, their horse artillery fired at 1,200 yards, or within the effective range of the small Gatling.

The traversing arrangement for spreading the shots during the time of firing, adapted to the Gatling gun, removes the objection raised against the French mitrailleur, that they carried so close as to put

several bullets into the same men; whilst the absence of recoil, enables the fire to be steady as well as continuous, the rapidity being regulated at the discretion of the firer.

The questions before this meeting are, first, whether the mitrailleur or Gatling is adapted for modern warfare under any circumstances. If so much be conceded, it remains to be settled whether it should be attached to infantry, or cavalry, or should form part of the artillery of an army.

On this point the balance of the evidence examined before the Committee inclined, with one exception, to making Gatlings a supplementary part of the artillery force. Not that they should be attached to artillery batteries, but that they should be treated tactically in a manner similar to that arm of the service. Great independence has, by a recent regulation, been given to Officers commanding batteries of field artillery. They are now required to support the operations of the other branches of the service, without hampering their action by conforming too precisely to their movements. So with Gatlings. Officers in command of "Gatling batteries" will require an especial tactical training, and will have to learn their proper employment in the field. If for purposes of organisation these batteries should be composed of twelve guns, it should be clearly understood that their division and subdivision for tactical employment would not only be probable, but would be almost certain, as I can conceive no situation where any large number of Gatlings could with profit be employed together. Their province would usually be to remain concealed behind some hastily raised breastwork, until the opportunity should arise of pouring forth their stream of deadly fire. To show themselves to artillery at the longer ranges in open country would be to court destruction; but to profit by their comparative insignificant size, and to bide their time until the enemy's infantry should advance, seems to be the *rôle* laid out for them in field operations. Now and then they might be called to the front, especially in enclosed country, but *defensive* rather than *offensive* tactics appear best suited for the full development of their powers.

As has been already stated, the Hungarian Government is reported to be in favour of attaching mitrailleurs to regiments of Militia, hoping by this means to give moral and material support to raw troops. To this opinion I would venture to dissent, on the following grounds:— Infantry ought, under the present conditions of warfare, to be rapid in movement. Preceded by clouds of skirmishers, and pressing onwards in successive waves, they must, when once engaged, sweep forward, availing themselves of all undulations of the ground for shelter from the enemy's fire. To wait for Gatlings, to rely upon them for support during their advance, or for cover when repulsed, would be to lose their elasticity, and would tend to lead men to depend upon extraneous help, rather than on their own rifles and bayonets. The very ground that infantry would select for action would be unsuitable for wheeled transport. Regimental Gatlings would either hamper the action of the troops to which they might be attached, or would be left uselessly in rear, vainly endeavouring to follow, and seeking fruitlessly for oppor-

tunities for coming into action. The reason against attaching field-guns to infantry would apply, only in a lesser degree, to uniting Gatlings with infantry. The action of artillery and of Gatling batteries should be separate from that of the infantry; each has its proper duty to perform, but these duties are distinct, and should consequently be kept separate.

None of the evidence was in favour of using Gatling batteries in place of horse artillery. The inferiority of their range to that of field-guns would probably lead to their destruction if opposed to horse artillery on open ground suitable for cavalry operations. It is, however, fair to say that no practical experience has elucidated this question, and that some Officers hold contrary opinions to that which I have ventured to suggest. That they will be found most useful for flank defence of ditches, for sweeping the approaches in front of field-works, for playing on the head of a sap, and for employment in the trenches and approaches of a besieging force, Engineer Officers will, I think, allow; their lightness, handiness of movement, the absence of recoil, and the continuity of their fire, seem peculiarly to fit them for such uses. The necessity for, and yet the difficulty of, bringing field guns into the advanced trenches to check sorties was felt during the siege of Sebastopol. The greater mobility of the Gatling, and its acknowledged superiority in deadliness of fire at short ranges to the 9-pounder field-gun, point to its employment in future sieges. How best to entrench it, is also a question to be decided by Engineer Officers. To restrict its action within the limits of an embrasure would be unduly to diminish its powers, and prevent the development of the sweeping fire caused by the lateral movement of the barrels as they successively discharge their shots. For the defence of defiles and of bridges Gatlings are well suited, although, on the other hand, for attack against entrenchments or barricades they appear to be almost valueless. For naval purposes such as have already been indicated, the Officers whom I have had the privilege of consulting, agree that they will be found very valuable, and to this opinion I have as yet heard no dissent.

In a paper written by Captain Rogers, which appeared in the January number of "Once a Week," it was suggested that Gatlings might be usefully employed in some of our colonies, when small numbers of Europeans may be engaged against savage tribes. They are easier to work than artillery, and consequently would be better adapted for comparatively untrained men, such as colonial Volunteers must, from the circumstances which surround them, frequently be. They are also readily moved through districts when the roads would scarcely admit of the passage of field-guns.

To all these points, and doubtless to others which have escaped my observation, I would direct your attention, and trusting that the evidence I have been able to collect may prove of use in enabling you to form conclusions on the important question involved in the employment or rejection of this description of weapon, I leave the matter in your hands, availing myself of this opportunity of thanking Colonel Wray, Captain Beaumont, the officers of this Institution, and others,

for the information they have afforded me on several technical matters relating to the subject.

The Mechanism of the Gun.—On the mechanical construction of the gun I have purposely refrained from touching, the subject of the lecture being the employment of the mitrailleur in war. A description of its several parts will be found in Mr. Gatling's paper, published in the Journal of the Institution, vol. xiv, whilst the gun itself is present for inspection.

On two points only do I wish to make remarks. A feeding apparatus consisting of a drum containing 336 cartridges has replaced the hopper previously used. Thus the rapidity of fire has been greatly increased, and the risk of the jamming of the cartridges removed. The diameter of the bore also has been made similar to that of the new Army rifle, the Martini-Henry. The ammunition is not, I regret to say, interchangeable, as the bottle-necked form of the Martini-Henry cartridge is unsuited to the mechanical method of loading the Gatling, from its not passing smoothly down the drum into the chamber. Possibly this defect, not in the gun or its cartridge, but in the uniformity of the armament of the Gatlings and of the infantry, may be remedied; but even if the former require a separate ammunition, I do not conceive that inconvenience in storage or in issue will be found to arise.

In conclusion I have only one observation to offer. History shows with no doubtful indications, that it is not merely to the improvement of arms that nations have owed their successes in war. To take the most recent instance. The French infantry were incomparably better armed than their opponents. They were taught to rely on their chassepôts and on their mitrailleurs, but they were not sufficiently instructed in the method of employing them. They were wanting in the steadiness and discipline which rapidly-firing arms require, and as their confidence in the new weapons had been unduly exalted, so when results failed to fulfil their anticipations, their *morale* became impaired. By all means furnish soldiers with the best arms that can be procured, but at the same teach them, that battles are not won by arms alone, but by that combination of courage, discipline, and skill, which pertains to vigorous nations, and to well-trained troops.

Captain ROGERS: As Colonel Fletcher has kindly alluded to me, I will offer a few remarks; and first of all, I may express the hope that an audience such as the present one will often meet within these walls to discuss, and listen to discussions, on subjects of such vast and paramount importance to the nation at large. There is one Gatling gun that Colonel Fletcher has not alluded to, one of small bore, 0·45; but I hardly think that it has yet been sent to England.* It also has ten barrels, but it weighs only 125 lbs. It is designed to be carried on the back of mules, camels, or elephants, or it can be mounted on a tripod (which enables it to sweep an entire circle), and be fired at the rate of 300 rounds per minute. Just consider what an admirable protection this would be for a small detachment at bay. Take, for instance, that small but unfortunate band of Jamaica volunteers, who, back to back, fought and fell around the Morant-Bay Court-house; how differently they would have fared if they had been in possession of such a gun. And throughout the mutiny in India, what an admirable

* This gun is now under trial.—ED.

auxiliary to self-protection in isolated positions, would have been this ingenious man-slayer. But apart from its deadly effects, there would be with the Gatling, under certain circumstances, an awe-inspiring moral effect, inestimable, except to men who have been placed in positions to understand the import of an unknown power, or to note its effects upon untutored minds. In this respect I may quote or parody ÆNEAS:—

"Quæque ipse miserrima vidi,
Et quorum pars '*parva*' fui."

In 1867 we had a "little war" in British Honduras, and on one occasion during it I witnessed the effects of rockets on Indians, effects which would have been ludicrous had they not been so serious. Scarcely had two or three rounds been sent over a village, than the enemy in utter consternation took to flight, betaking themselves with frightful yells into the surrounding bush. Now such a Gatling as I have described would, no doubt, have produced the same amount of abject terror: but how many also would it not have placed *hors de combat!* The rockets, however, did their work of frightening only too well, for these eccentric missiles went harmlessly over the heads of the Indians who "lived to fight another day." Most of our future wars will be on a comparatively small scale. We cannot, if we would, muster the big battalions that marched majestically over the desolated plains of France. Consequently our future fighting operations will be more or less connected with those "who go down to the sea in ships and have their occupation on the great waters;" and in such hastily organised expeditions as *distance* will impose upon us, can any gun be more admirably adapted to the work than the Gatling? But in all English colonies the monopoly of possession should be secured to the Government for this reason, that hitherto, in a spirit of freedom, we have allowed our merchants to supply ammunition and material of war to the very factions or rebels whom we are called upon from time to time to fight. I have myself witnessed the effects of this disastrous policy on the West Coast of Africa, where the very merchants, who urged on "war to the knife" in protection of their homes and property in their mercantile capacity, were furnishing the enemy with the means of destruction. This should be looked to. I will merely add, that in future wars of this character, if the Government should send out Gatlings to colonial stations, local ordinances should be enacted to prevent the importation of such guns by the natives.

Captain H. BRACKENBURY, R.A.: Col. Fletcher has quoted evidence of mine as to what I saw after the battle of Sedan. I very much regret that when I was summoned before the Committee, I had not then had the opportunity which I subsequently had of visiting and studying with great care all the battle-fields of the war in which the original French Army fought. I have since, in going over those fields, seen more than one place where the effect of the mitrailleuse had been most deadly. There is that wonderful instance of the ravine close to the *Bois des Ognons*, at Rezonville. Now we have very plain evidence as to whether the French considered the mitrailleuses to be more effective than guns in certain positions, by this fact, that Marshal Bazaine, who was there on the spot himself, had plenty of guns under his hand, but had only two batteries of mitrailleuses: and to defend the head of that ravine (this was after having seen previous battles), he brought up his mitrailleuses. Anyone who has seen that battle-field, who has seen the way in which the graves are at this point piled almost one upon another, will see how awful the slaughter must have been, and it was due, practically, entirely, to these mitrailleuses. There is another peculiar case, and that is on the western side of the battle-field of Sedan. On the heights, close to Floing, there was placed a battery of mitrailleuses. There is opposite to that a round hill with wood on the top, and out of this wood and from behind this hill came the Prussian columns; as they came out they were swept down by these mitrailleuses, and they did not succeed; they could not make any progress, they were obliged to go back again and go round on the reverse slope of the hill, checked by the mitrailleuses. There is another example I might give where the mitrailleuse did remarkable work, that is in defence of the railway bridge at Bazeilles. The Bavarian columns came down and endeavoured to cross that railway bridge, of course, preceded by their skirmishers. Two mitrailleuses only, I believe, were placed behind a garden wall, and they simply swept that bridge, so that the Bavarians could not pass it. These are instances of what the mitrailleuse can do. Now, I have lately

been passing the Christmas and the new year with Marshal Canrobert, who commanded the sixth corps on the right of the French position at the battle-field of Gravelotte. I have had the advantage of talking not only to his staff, but also to some of the staff of General Ladmirault, who commanded the Fourth corps. I hear from the Sixth corps one universal expression of regret that they had no mitrailleuses. "If we had mitrailleuses to place behind those walls at St. Privat and those farm "buildings of Jerusalem on the road, not only would the Prussian Guard have been "repulsed as they were more than once by our infantry, but when our infantry had "become demoralised by their crushing artillery fire, had mitrailleuses been placed "behind those walls it would have prevented their coming up again." I noticed this also on this battle-field of St. Privat. The Guard attacked in two bodies, on the right of the road and on the left of the road. On the right of the road as they came up there were the mitrailleuses of Ladmirault's corps, on the left of the road there were no mitrailleuses in Canrobert's corps. The columns on the right of the road suffered much more than the columns on the left of the road; I do not say entirely owing to the mitrailleuses, but I give you that as a fact. These are instances in which the mitrailleuse has been very formidable. Certainly those French artillery Officers whom I have asked about it, are strongly in favour of retaining the mitrailleuse in their army; but they all agree in saying that their artillerymen must be taught better how to use them. There is no question whatever that they fired away their cartridges at 1,500 and 2,000 yards against the enemy's troops almost as soon as they came in sight, and the result was that when the enemy came up to the mitrailleuses in position they had sometimes no cartridges to fire. It was the same to a certain extent, with the chassepôt.

There are positions in which the mitrailleuses are invaluable, but I must say if we are to introduce them into our service I want to see a lighter carriage than the one before us. I want to see a carriage with less width between the wheels and of a lighter construction; I want to see a carriage that can be run into a building; knock down a bit of the wall, run the mitrailleuse into the building, knock a hole through the wall, and on the enemy's side put the muzzle through the hole. You cannot make a wall full of loopholes; if you do it scarcely offers any resistance, and infantry do not like standing behind it; but place a mitrailleuse at a loophole and what a tremendous effect will be produced! And mark how much on the battle-field depends upon holding certain positions, such as villages and farm buildings. I believe that behind the walls of such buildings the mitrailleuse will be invaluable; but as to using the mitrailleuse in the attack, it is clearly evident that that is impossible. What is the principle of attack now? What do we see in all those battle-fields but one single plan of attack? First the infantry is utterly demoralised by the crushing fire of a mass of artillery concentrated upon it, then masses of skirmishers or columns are sent up to attack. What can you do with the mitrailleuses? they are of no use in the attack; but in the defence, I believe in certain positions, they are invaluable, and I hope that we shall see them introduced into our army, but not hampering infantry by being rigidly attached to them. I must object to batteries of twelve guns. I never saw a position (except in the open, where of course they are liable to be crushed by the long-range artillery fire of the enemy) where you could place a battery of twelve mitrailleuses, and when you get behind a building you could never get twelve mitrailleuses together. Why attempt an impossibility like that? Why not be content with a battery of three or four mitrailleuses?

General ADYE, C.B., R.A.: Having had occasion for some time past to study this question, I am anxious to address a few words to the present meeting. I quite agree with what has been said as to its importance, and consider it a very proper subject to be discussed in this Institution; and we may congratulate ourselves on the impartial and excellent manner in which Colonel Fletcher has brought it before us. The subject of mitrailleuse is not a new one, as Colonel Fletcher has pointed out to us; but hitherto it has had little success. Within the last few years, however, the subject has revived. We became acquainted with the fact that the Prussians had made careful experiments, and had rejected mitrailleurs, and that the French had taken the opposite view, had adopted them largely and prepared many batteries which they produced in the field in the recent war. We on our part understood that the Montigny mitrailleur and the Gatling had been much improved in their mechanism, and were

stated to be also improved in their power. Therefore, we made careful experiments, and the result was that we have, to a certain extent, adopted the gun which is before you. Now, in considering the uses of the mitrailleur with an army, we must remember that in its general attributes it is a field gun; that is to say, mounted on a wheel carriage, it requires horses for its draught, men to man it, and waggons for its ammunition. Therefore, it has the *impedimenta*, in proportion to its weight, and the exposure, of field artillery. When we examine the experiments that have been made, we find that it has one advantage, namely, that within the limits of musketry range, it can pour more bullets into columns of troops advancing in the open than a field gun. That is a great advantage, but it is its only one. We must remember, that a field gun has a great incendiary power; it can set fire to villages, destroy walls, stockades, and entrenchments; it can smash and overturn the enemy's artillery, their ammunition waggons, and their baggage; while in all these respects the mitrailleuse is powerless. So that whilst the mitrailleur intensifies the power of artillery in one respect within limited ranges, it does so at the sacrifice of all those qualities which make field artillery so formidable. It does one thing well, and the rest not at all. Now, that to my mind is a very important matter. We are told again that the mitrailleur is of no use for attack, but only for defence. And we are told that the French did not display its qualities well; that, however, is rather a peculiar argument to use, because the French were on the defensive the whole time, and, therefore, one would have thought that if it has peculiar qualities for defence they would have come out in the French war. Up to the present moment I have been speaking of the mitrailleur as compared to the field gun within the limits of musketry range. We must, however, remember, that beyond those limits, the field-gun goes on increasing its effects up to two or three thousand yards; and all that time the mitrailleur is silent. This is another important question to consider. Infantry troops supported by mitrailleurs might, I think, be disheartened, if they found that they were played upon by the enemy's artillery, whilst their own mitrailleurs could make no reply. I had the advantage of speaking to a distinguished Prussian General Officer some short time ago, and what he told me was this, that when (during the last war) they discovered the position of the French mitrailleurs in action, they played upon them with artillery at long range, and snuffed them out; they drove them off the field; for the very reason that I have attempted to explain, that the mitrailleur was incapable of reply. I have a great regard for the military opinion of the French, but in my opinion (formed before the war) they committed an error in their hasty adoption of mitrailleurs. They did so with a certain amount of mystery and secrecy which for the moment, perhaps, enhanced their value, but which in the end achieved no object. Those who argue in favour of the mitrailleur, will tell you, that they do not contemplate the reduction of a single gun, but would take them in addition to a full proportion of field artillery. But here another difficulty meets us. What are the rules which determine the proportion of guns in the field? What is it that limits their number with an army? Why do we lay down a rule that about three guns per thousand men at the most can be advantageously employed? Because when the *impedimenta* of artillery reach a certain point, we find that artillery, instead of being an advantage and a support to an army, tend to hamper and embarrass it. As an artillery Officer, it is not likely that I should depreciate or ignore the great power of the arm; but I acknowledge, and all artillerymen acknowledge, that there are limits in these matters. If you will allow me, I will read to you the opinions of another artilleryman, an Officer who is a great authority, Colonel Hamley. In his "Operations of War," speaking of the campaign of 1859 of the Austrians, he says:—"The reader will have noted that both at "Austerlitz and at Solferino, the beaten armies brought to the field a great preponderance of artillery, a large part of which took no part in the engagement. The "truth is, that the huge trains which followed their columns were too unwieldy to "be arrayed. Surplus artillery is far worse than useless; it hampers and delays the "columns, destroys roads, perplexes Generals, keeps troops out of action for its "escort and protection, and impedes the retreat. The proportion of guns to men "at Solferino, namely $2\frac{2}{3}$ to 1,000, is probably as large as can exist with advantage "in great armies. This is more than ever true, since the increased mobility of artillery, and the widened sweep of its horizon, have augmented its effect compared

"with its numbers." Therefore, those who argue that you should take the full proportion of artillery, not diminishing a gun or a man, and still take the mitrailleurs in addition, have to explain how they will overcome this difficulty. I am informed that a distinguished General Officer, Prince Frederick Charles, says:—"If you are "able to take more wheels, more *impedimenta*, more weapons into the field of that "kind, then give me more artillery." That is, he would prefer additional field guns rather than mitrailleurs. It is also stated that the mitrailleurs may be useful against boat attacks. Well, it appears to me to be a question whether a gun which will fire a shot to cut a boat in half and sink it, may not be a more effective weapon even in that respect than pelting them with a shower of bullets. I have not alluded to the expense, nor have I alluded to the comparative delicacy of the weapon. Its expense is very considerable; I believe it is about £220 or £230 compared with £90, the cost of a 9-pounder field gun. That is, however, not a material point, if the great principle is established, that mitrailleurs are useful in the field; its delicacy also might perhaps be overcome. Therefore, what we have to consider is, the probable use of mitrailleurs in the wars of the future? It is important to my mind that public opinion should be formed upon this point. I do not think it is formed yet. And it is very important also—it is essential—that military men should take the lead in forming this opinion; that we must exercise great care and caution before we allow ourselves to be run away with by comparatively untried novelties. We must deliberately see whether by adding mitrailleurs to the Army, we shall increase our powers. Possibly for certain limited fixed positions for defence these weapons may be useful. But, as far as my experience goes, it is this, that we require in modern battles long-ranging, hard-hitting weapons, such as I believe we possess in the present rifled muzzle-loading 9-pounders and 16-pounders. Therefore, it is to me a great question, whether we shall do wisely in taking mitrailleurs into the field. I have thought considerably about the matter for some time, and believe that the uses of mitrailleurs must always be of a limited and exceptional character.

Captain BEAMISH, R.N.: I did not come here with the intention of making any observations upon the question before us, because I had not had the opportunities which I should have liked to have had, of learning all about the weapon. Further than that, I have read little about it. But during the course of the evening I have heard all that has been said, and having paid attention to it, I would ask your permission to make one or two observations as to the part that I think the Gatling gun (not necessarily so large a gun as that) might take in naval matters. First, I am disposed to think that I should not like to see it substituted for guns in boats altogether, only partially. In all matters of naval attack where boats are used, it is absolutely necessary to cover the attack that is made by the boats. It occurs occasionally, but really not very often, that the ships from which the boats are detached can cover the landing; but very generally it does not so occur, and the boats themselves have to cover their own attack. I have had at times formerly, a little experience of something of the sort, and I have suffered greatly, or rather seen a great deal of suffering from the effects of not being able to cover our own attack, partly because of the recoil of the guns in the boats. This is not likely to be the case, as I understand, with the Gatling gun; and more than that, instead of being worked by four or six men, it can be worked by two. Therefore, not requiring more than two men to work it, the gun can be worked all the time that you are pulling towards the landing place to cover your landing. I think if well-trained men had to use it, they would work the machinery without any great distraction, and without any great mistakes. As I said before, it might not be necessarily substituted for guns in boats, such as the guns we usually carry, which are the Armstrong breech-loading guns; but I think there might be put, perhaps, one into each ship, and certainly one into each of our large ten- or twelve-oared cutters, which could easily carry them, and which now can carry no gun. With regard to an observation made by General Adye about the Gatling not being valuable against the landing of boats, I, on the contrary, think it would be extremely valuable, for its range is large, and it is not at all an easy thing to hit a boat with a round shot; but it is an extremely easy thing, when firing at a straight pulling, narrow object like a boat, to cover it with a Gatling. Moreover, it is extremely valuable in a boat to keep down the fire of any Gatling that may be on shore. It strikes me that it has got another advantage about it, which is

particularly valuable. The projectiles that we have for boats are shell, round shot, and shrapnel. We do not fire case out of an Armstrong. Ordinarily, you are obliged to cut the fuses. It is, too, a most awkward thing to keep your ammunition in the stern of your boat; certainly, your fuses are always cut there. There is a great deal of confusion in cutting fuses, when every moment of your progress you are constantly altering your range, so that, however many fuses you cut beforehand, you hardly ever have fuses so accurately cut that they can do the work that a Gatling could do, for you can constantly work the latter all the way to the landing. I think that is a great advantage. I think there would be great advantages in the use of the gun if we could put a small one into every large boat which carries a gun, and into every cutter that does not carry a gun. If you could get a light Gatling, such as was mentioned by Captain Rogers, or a gun between the one I see before me and the one he mentioned, a small boat could carry it, and it would be a very effective weapon. Lastly, on board ship they would be very valuable in the tops round which screens are always placed now-a-days; they would add greatly to the efficiency of rifle fire, and keep down that of the enemy. And if we are to have men-of-war rammed, there is no doubt that the crew of the vessel that rams another will make a struggle to get on board the other; and in that case a well-placed Gatling, well aft or well forward, could keep the side of the deck on which the enemy came on board positively clear, some of their own men being on the other side, and some of them in the rear.

Colonel WRAY, C.B., R.A: I should like to explain a remark made by Captain Brackenbury with reference to the organisation of the battery of twelve guns, for which I am responsible. They are placed in batteries of twelve simply for the sake of organisation. You can see by the number of officers employed that a battery can be broken up into any number of parts. It was never intended that they should be taken into the field as a battery of twelve, or used as a battery of twelve. I think you can hardly look at those tables and study them carefully, without being satisfied that there are some good qualities about the Gatling. For instance, if you take the space covered by a battery of twelve, you find that it takes up about half the space of a 9-pounder battery of six guns. Then again it takes only half the number of men and horses. Again, it delivers, in comparison with the weight of ammunition carried, three times the destructive effect up to 1,200 yards, and, I believe, up to 1,600 yards, though as yet it has not been tried up to that range. Therefore with a battery of twelve Gatlings you can get the effect of thirty-six guns, or six field batteries up to 1,200 yards for resisting attacks. The Committee never proposed that they should be used for attack, but simply in defence. It unfortunately happened at Shoeburyness, when H.R.H. the Duke of Cambridge came down to see the "Gatling" fired, the gun was not sighted, and the practice was most indifferent; in fact, the result was such that the whole of the Committee were strongly opposed to the Gatling as strongly as anybody could be. After trying it for six weeks,—and we took a great deal of trouble,—the Committee came to the conclusion that there was some good in the weapon. And I believe a good many people who are now against the gun, will by this time next year be of the opposite opinion.

Colonel FLETCHER: There are very few remarks requiring answers from me, because many of the objections that have been raised against the Gatling have been answered by Officers present in a much more effective manner than I can do. I was very glad that Colonel Wray explained to Captain Brackenbury that the organization of the Gatlings in batteries of twelve guns was simply as a means for organization and not for tactical purposes. Because I agree with Captain Brackenbury, that it would be impossible to find any position where batteries of twelve guns could be employed. I look upon two or three guns as the largest number that could be brought together in any particular place for purposes of defence. One remark made by General Adye I should like to say something about. He drew attention to what had passed between a distinguished Prussian Officer and himself with reference to the manner in which the Gatlings were knocked over by the Prussian artillery whenever they showed themselves on the field. When Colonel Reilly was present at one of the battles before Orleans, he distinctly saw batteries of mitrailleurs in the open, employed for a considerable time within 1,200 yards of the Prussian horse artillery, and the horse artillery did not touch them during the whole of that time.

In reference to the comparison between Gatlings and artillery, I think there are elements of error in artillery fire which, to a certain degree, are greater than those in the Gatling. I quite agree that with the Gatling there is a difficulty in ascertaining the range; there is not the opportunity of seeing where the shots strike as when a shell is fired from artillery. On the other hand, there is not the element of error inseparable from the employment of fuses. Any person who has watched artillery fire, must have been struck with the error consequent on faults in the fuses; either they do not act properly, or they burn too quickly, or too slowly. I am speaking of time-fuses. Consequently it is, I think, fair to the Gatling to give it so much advantage in its comparison with artillery. Then with regard to the expense of the Gatling as compared with that of the field gun, although the Gatling itself may be more expensive in manufacture than the field gun, yet, if you compare the two together, and take into consideration the greater expense of horsing and manning the field gun, I think you will find the cost of the Gatling is considerably less. I was rather struck with a remark of Captain Brackenbury with regard to lightening the carriage. It is a subject upon which I feel I am not competent to give an opinion; but, if it be possible to lighten the carriage and make it smaller, there can be no doubt a great improvement would be effected. I am also glad to hear what Captain Beamish said with reference to the adoption of Gatlings for boat operations. The opinion of a naval Officer on this subject is of great value, because the question has not been much discussed by naval Officers, and we have not, therefore, had the advantage of hearing their opinions. In conclusion, I would remark that the great question is, whether the advantages of the Gatling counterbalance the increased *impedimenta* which it must necessarily entail in warfare. The *impedimenta* entailed by a battery of Gatlings has been shown by Colonel Wray's table, which gives the length in yards occupied by twelve Gatlings as compared with six 9-pounders, to be considerably less than the *impedimenta* of field artillery. But if you add Gatlings to your field artillery you increase your *impedimenta* in the same way that if you add ammunition carts to infantry consequent on the increased number of rounds now necessary, you increase the *impedimenta*. The whole question is one of degree. If you wish to have an arm between artillery and infantry, you must make up your mind to have the increased *impedimenta* which that arm will entail. I think the real point which both artillery and naval Officers ought to consider, is the right employment of the Gatlings, and how and in what positions the full development of the deadly fire, which no doubt they possess, can best be attained.

The CHAIRMAN: Before asking you to accord, as you will heartily do, your thanks to Colonel Fletcher for his able and unprejudiced statement of the subject, I may be allowed to make a few remarks. It appears to be generally agreed by the meeting that this weapon is certainly available for, and is likely to be a very valuable aid in, defence. As regards attack we should not decide hastily against it, as experience shows that many modifications of existings modes in war are necessarily taking place. Nor can it be said that the proportion of artillery to infantry is so rigidly fixed as not to admit of relaxation, as regards the *impedimenta* of that branch, if experience shows its necessity. If the system is to be looked upon as one for defence *only*, it is likely that there will soon arise some difficulty in its application, as it will come to be considered as a mere reserve, and will seldom be found ready at the critical moment when it is most needed. All, however, appear to be agreed that as regards specific positions, defence of bridges, and such like, it is an important arm.

Colonel Fletcher has put the question fairly when he asks, "Is the advantage com-
"mensurate with the additional expense and trouble and the addition to the *impedi-*
"*menta* of an army?" At present the answer to this question is left among very divided opinions.

As regards the weapon itself, though it has only become possible with the increased mechanical skill of the day, I confess that I am not at all satisfied with the arrangement by which the drum for holding the cartridges is placed in so exposed a position. It seems more than probable that a single ordinary rifle bullet striking the drum, even if it did not explode the whole of the contents, would so far injure thearrangement as to render it temporarily useless.*

* It will be seen, on referring to the plate, that the drum is now protected from fire.—ED.

I will now convey to Colonel Fletcher the thanks of the meeting for his paper, which bears such evident marks of the ability which he has brought to bear on the service of the Committee of which he is so active a member.

MEMORANDUM BY MAJOR-GENERAL CAMERON SHUTE, C.B., late Commanding 4th Dragoon Guards.

Lieut.-Colonel Fletcher's interesting paper tends strongly to prove that mitrailleurs are likely to be employed in future wars.

The three questions, then, arising, from his observations, which I would very shortly argue, are the following, viz. :—

1st. Should mitrailleurs be attached to each infantry battalion as part of its establishment?

2nd. Should they be similarly attached to each cavalry regiment?

3rdly. Should they be formed and equipped in batteries of eight or twelve guns and form a portion of the Artillery Service?

First, then, as regards infantry. If mitrailleurs—say two guns—formed part of the regulated establishment of a battalion, this must entail the necessity for well-instructed farriers, wheelers, saddlers, non-commissioned Officers, and men who can ride and understand the care of horses, besides a considerable reserve of others qualified to fill up casualties, as well as spare horses, to replace the sick, lame, killed or wounded; and a special commissariat establishment.

We must, then, next consider how far the value of these guns, for the usual exigencies of the infantry service, would justify a battery of them, constituting, so to say, an integral part of a battalion.

Doubtless they would occasionally prove very effective on "outpost duty," particularly where a piquet has orders to hold the ground entrusted to it, perhaps a gorge, defile, or important cross-road, and to defend it to the last; also in the defence of bridges, or in retreating through streets, or by roads and lanes, though in the latter cases, great care must be taken to prevent an enemy from taking them in flank by detaching skirmishers across the country on either side.

In but few other instances would these guns be of more value than the rifles of the battalion to which they were attached. For to open an attack for infantry, it is generally desirable that the supporting guns should be capable of acting with effect against troops covered by shelter-trenches, woods, buildings, fences, banks, walls, &c.

Again, with infantry acting on the defensive,—if the position be judiciously selected,—their well-protected artillery should have free scope for their full length of range, so that the attacking enemy should of necessity be exposed to the devastating and demoralising effect of their fire over from 2,000 to 3,000 yards of their advance, and to which even their supports and reserves should gradually become exposed.

If, then, I am correct in believing that in neither of the latter instances would mitrailleurs give the desired support, I am decidedly of opinion, that we should not be justified in adding a battery of them to each battalion, requiring as it would, a complicated and expensive esta-

blishment, foreign to the arm, and which the commanding Officer, unaccustomed to the many details of mounted troops, would but ill supervise; whilst the guns, only able to move along roads, lanes, or open cavalry country, would either hamper the infantry movements, or under the protection of a strong escort be left in the rear, tending, perhaps, to block up the line of march for other troops.

Next, let us consider whether the objections advanced to "mitrailleurs being attached to battalions of infantry," equally apply to the case of cavalry regiments.

First, then, as regards the cost; this would be extremely small. Farriers, saddlers, drivers, mounted Non-commissioned Officers and men, horses, and a reserve of horses, are already there, though it would be advisable to have an extra armourer, and two at least of the saddle-tree makers should also be instructed as "wheelers."

The Serjeant-Instructor of Musketry should be made "Gun-Serjeant "Major," and could soon be qualified to instruct a given number of Non-commissioned Officers and men in each troop of regiments in which all ranks are already carefully practised in "aiming and judging distances." Supposing there to be a gun per squadron, a serjeant selected for this purpose would, for ordinary occasions, be in charge; but when the four guns were concentrated, the battery would be officered from the Captains and Subalterns who had taken first-class certificates at Hythe or Fleetwood, and of course should be specially drilled with those guns, and who would better understand how to give efficient support to the attack or retreat of their own arm than Officers of another branch of the service.

Now as to the general utility of mitrailleurs attached to mounted corps.

With cavalry they would be valuable for outpost duty, on exactly the same occasions as those previously enumerated with reference to infantry; and at night, when—as should almost invariably be the case—the cavalry piquets and videttes are withdrawn (these duties after dark devolving on the infantry), the mitrailleurs, with a proportion of mounted orderlies, should be left with the piquets or supports of the latter force.

A gun per squadron would also advantageously accompany strong "Reconnoitring Patrols" and "Patrols in pursuit;" and during a retreat, would render a rear-guard of cavalry comparatively independent of the other arms, particularly in the streets of towns and villages, where the front is necessarily restricted, and were the range is limited; also in roads and lanes, the flanks being covered by dismounted men.

Acting on the offensive, cavalry do not attack troops covered by impediments, but in an open country, where batteries of mitrailleurs are specially effective; and if well handled, they would give most effective support, for the Officers commanding them should manœuvre to occupy positions *within* 1,400 yards' range of an enemy's artillery, and *above* 1,000 yards distant from his infantry, availing themselves of natural cover such as undulations of ground, &c.

Admitting, then, that mitrailleurs attached permanently to cavalry regiments (not Lancers) would be both inexpensive and useful, the description of "machine-gun" best suited to the purpose must next be considered. It must be strong, yet so light as with a view to simplify driving, and for other important reasons, to be easily manœuvred with two horses, and over ground not practicable to ordinary artillery; it should hamper roads as little as possible, and be easily reversed in the narrowest lanes; should be capable of being worked by three men, and the ammunition waggon must carry the reserve rifle-cartridges of the squadron to which the gun is attached. It should be a "continuous-"firing," that is a "repeating-gun," so that it should not be necessary,—as with artillery,—always to have at least two guns in action at a time, one supporting the other; it should have no recoil, and should not require re-sighting or re-laying, but, firing a shot at a time, allow of a lateral, sweeping motion being kept up during firing, all of which requisites, I believe, are to be found in the "Gatling gun."

With the cavalry division in the Crimea there were three troops of horse artillery, and a half troop without guns, to carry the reserve carbine ammunition; had there been "Gatling guns" attached to regiments, two batteries and the half troop might have been spared by the cavalry, and employed as part of the Artillery of Reserve, where horse-artillery are so specially valuable.

The third question for argument is whether "mitrailleurs should "be formed into batteries of eight or twelve guns each, and should form "part of our artillery force." In reply, I am strongly inclined to think that as this would entail an establishment consisting of a first and second Captain, three Lieutenants, an Assistant-Surgeon, a Veterinary Surgeon, a Sergeant-Major, a Quartermaster Sergeant, &c., &c.,—in fact be nearly as costly as a complete battery of our present field-guns;—I would rather not replace them with mitrailleurs.

I may add that upwards of two years ago I suggested to a military authority that permission should be given for the experiment of the system of attaching "Gatling guns" to cavalry in the proportion of one to each wing, or squadron, being tried in the regiment under my command, and which was then, and is now, at the head of the cavalry as regards "musketry," all ranks being as carefully instructed in "dismounted practice" and the use of fire arms, as was compatible with the greater cavalry essentials.

THE CHOBHAM CAMP BEDSTEAD, CONVERTIBLE INTO A TABLE AND TWO STOOLS.

Invented and described by CONRAD A. DILLON, Esq., Captain 36th Middlesex Rifle Volunteers.

THE patented invention which I have the honour to submit to you this evening is so simple in construction, and its uses are so obvious, that it hardly needs any remarks. It consists of three parts, a table and two stools, which, by a simple contrivance, are convertible into a camp bedstead. The great want which exists in camp, of a table of the ordinary height, with a stool in proportion, is beyond all question. Whether it be for writing or drawing, a table is almost indispensable, and the various makeshifts and contrivances hitherto resorted to, have never completely satisfied all the different requirements.

So far as the bedstead is concerned, it is, I believe, generally considered to be (though of course not a necessity) a most valuable addition for camp life, being the only real protection from damp and the ills which accompany it. Being disembarassed of one's bedstead during the day, in the confined space of a bell tent, is by no means a slight advantage gained by the adoption of this patent.

FIG. 2.

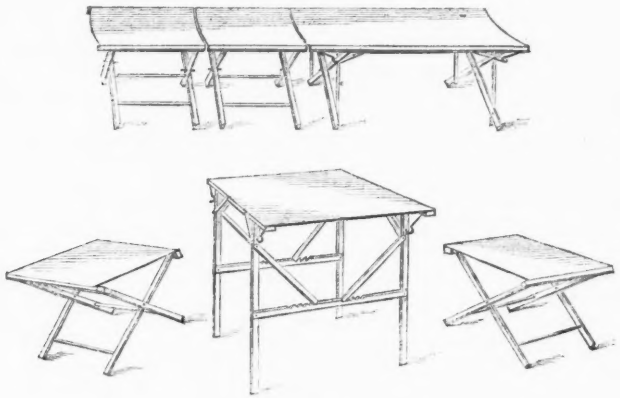


FIG. 1.

The table consists of a piece of canvas stretched tightly on two horizontal bars resting on four legs, which are connected by two cross-bars. The head is kept stretched by four struts fastened to the four legs, and working in notches on the cross-bars (Fig. 1).

For all the ordinary uses of a table, the canvas will be found sufficient; for drawing, a panel-drawing-board resting on the two horizontal bars will be found to make a table almost equal to any ordinary house

table. Wooden mats, which will roll up, are also most convenient for making a stiff top to the table. The four legs are connected with the horizontal bars, into which they fit by means of a joint, like the ramrod of a cavalry carbine, and are made perfectly secure by four hooks. The cross-bars, the only loose pieces, connect the legs by means of screws, themselves permanently attached to their respective places. The camp stools are of the ordinary construction, as it is not considered advisable to sacrifice strength and stability.

To form the bed, the struts of the table are thrown out of gear, and the cross-bars taken off (Fig. 2). The legs are then crossed and made fast by the two screws which are attached to the outer legs. The hanging struts which are turned out, serve to support the stool thus formed, in case of any unusual weight being placed upon it. The three stools are then placed in a row, and connected by the couple at the ends of the horizontal bars.

The size of the bedstead is about 6 ft. by 2 ft., but it can be had any length required. The table is 3 ft. by 2 ft. $2\frac{1}{2}$ in., and 2 ft. 6 in. high. The stools are 2 ft. by 18 in., and are about 18 in. high.

The total weight is about 20 lbs. (that is of these, which are of American Ash), but that of course can be diminished or increased according to the wood, the thickness of the canvas, and the strength of the couples. The dimensions of the whole packed for transport, are 3 ft. by 18 in. by 9 in., or about $3\frac{1}{2}$ cubic feet which includes a large space available for bedding, clothes, &c.

The drawing-board weighs $3\frac{1}{4}$ lb. The German Mat about 5 lbs.

I have submitted the invention to several gentlemen of experience, and the only objections which have hitherto been raised, have been against the size and weight; in reply to which objections I may state, that I believe this to be the smallest and lightest form in which a stool, table, and bedstead are at present made.

In reply to questions, Mr. Dillon said that, on an uneven surface the legs of the bed could be driven into the ground, and as it was held together by iron couplings, there was no chance of its giving way. The cost was £2 5*s*.

The CHAIRMAN: We thank Mr. Dillon for exhibiting this ingenious contrivance; in the next campaign in England we shall perhaps see it in use.

Evening Meeting.

Monday, January 29, 1872.

Vice-Admiral SIR FREDERICK W. E. NICOLSON, Bart., C.B., Vice President, in the Chair.

NAMES OF MEMBERS who joined the Institution between the 23rd and 29th January, 1872.

LIFE.

Wharton, W. J. L., Lieut. R.N.
Griffiths, M. R. M., Lieut. R.N.
Dawnay, Hon. Eustace H., Lieut. Coldm. Guards.
Monck, Hon. Henry P. C. S., Lieut. Coldm. Guards.
Gordon, Lord Douglas W. C., Lieut. Coldm. Guards.
Acheson, Hon. E. A. Brabazon, Capt. Coldm. Guards.
Ossulston, Charles Lord, Lieut. Coldm. Guards.

ANNUAL.

Money, E. C., Capt. 87th Regiment.
Rawes, W. W., Lieut. R.A.
De Kantzow, Herbert P., Capt. R.N.
Brancker, William G., Capt. R.A.
Ormsby, Geo. F., Capt. 2nd Dragoon Guards.
O'Brien, A. V., Lieut. 60th Rifles.
Brownrigg, Henry S., Lieut. Rifle Brigade.
Alexander, Caledon J., Capt. Coldm. Guards.
Mackinnon, L. D., Lieut. Coldm. Guards.
Sich, Arthur J., Lieut. 2nd Middlesex Rifle Volunteers.

MODERN SHIPS OF WAR, AS ILLUSTRATED BY THE MODELS IN THE ROYAL UNITED SERVICE INSTITUTION.

By NATHANIEL BARNABY, Esq., Assistant Constructor of the Navy.

On the 11th May, 1859, the first English sea-going ironclad—the "Warrior"—was ordered to be built, and she was quickly followed by the "Black Prince," the "Defence," and the "Resistance." Their advent was the signal for the inauguration of a new Navy, in which wooden ships of the line and frigates could hardly hold a place. The "Gloire" and "Invincible" had at this date (May, 1859,) already been a year in hand, and the French had commenced, or were on the point of commencing, the "Magenta," "Solferino," "Couronne," and "Normandie." Yet so little had the change thus inaugurated been foreseen, that in this year (1859) and the year succeeding it, 1860, the following ships were launched or had their conversion com-

pleted as screw ships, viz., Ships of the line, "Victoria," "Howe," "Duncan," "Gibraltar," "Anson," "Atlas," "Prince of Wales," "Revenge," "Hood," "Conqueror," "Neptune," "Frederick William," "St. George," "Trafalgar," "Irresistible," "Lion," and "Queen." Frigates: "Immortalité," "Liverpool," "Newcastle," "Phœbe," "Severn," "Narcissus," "Phaeton," "Ariadne," "Galatea," and "Bacchante." And at the end of 1860 there still remained incomplete upon the stocks, or being converted, the "Prince Regent," "Defiance," "Bulwark," "Robust," "Repulse," "Albion;" "Zealous," "Royal Alfred," "Royal Oak," "Triumph," ("Prince Consort,") "Caledonia," and "Ocean," line-of-battle ships, and the "Bristol," "Glasgow," "Undaunted," "Arethusa," "Constance," "Octavia," "Aurora," "Endymion," "Dryad," "Tweed," "Belvidera," "Dartmouth," and "Ister" frigates; all these being designed to be built of wood, and unarmoured.

So late as January, 1860, a new classification of ships was ordered, of which the first, second, and third rates were as follows:—

First Rates.—All ships carrying 110 guns and upwards; and of which the complements were 1,000 men and upwards.

Second Rates.—All ships carrying under 110 guns and more than 80 guns; or with complements under 1,100 and not less than 800 men.

Third Rates.—All ships carrying 80 guns, or not less than 60 guns; and with complements under 800 and more than 600 men.

"*Howe*," "*Duncan*," *and* "*Ariadne*."

Among the ships which I have named as being produced at this period (1859-60) are three, models of which are in the Museum of this Institution, viz., the "Howe," "Duncan," and "Ariadne," of 121, 101, and 26 guns respectively. The cost of these ships complete, with the exception of ordnance and ordnance stores, would be represented by nearly £250,000, £200,000, and £150,000 respectively.

The armament designed for the "Howe" was 64 guns of 65 cwt. each; 34 of 56 cwt. each; 22 of 42 cwt. each; and 1 68-pounder pivot gun.

That designed for the "Duncan" was 38 guns, of 65 cwt. each; 38 of 56 cwt. each; 24 of 42 cwt. each; and 1 68-pounder pivot gun.

That designed for the "Ariadne" was 24 guns, of 84 cwt. each; and 2 68-pounder pivots.

I may be excused, I think, from giving any other particulars with regard to these ships further than to say that the "Howe" has never been completed for sea, and is now a divisional ship at Devonport; the "Duncan" is in the First Division of Reserve at Sheerness; and the "Ariadne" has just been completed as a training-ship for Cadets.

I ought, perhaps, also to say that the "Howe" has no sister ship; that the "Duncan" had or was intended to have the following sisters (not precisely identical, but nearly so) "Gibraltar," "Repulse," "Bulwark," "Zealous," "Robust," "Royal Alfred," "Royal Oak," "Triumph" or "Prince Consort," "Caledonia," and "Ocean." Of these seven have been cut down and converted into ironclads, and two are still on the

stocks. The only sister ship completed, (the "Gibraltar") has just been lent to the Belfast Training-Ship-Committee for training poor Irish boys for seamen. The "Ariadne" has but one sister, viz., the "Galatea." Ten years ago, the ships of which these three models are representatives, were looked upon as perfect, and all the resources of our dockyards were taxed to the utmost to produce them. There were purveyors in every forest in England and in Italy, marking for immediate use the largest timber which could be found for stems, stern-posts and frames. In some cases the timber was worked into the ship only a few weeks after it had been standing full of life in the heart of the forest. To-day we regard them as ships of the past, obsolete, and nearly useless.

It may be that our prescience of to-day is no better than that of our predecessors, and that ten years hence, our works too may be obsolete. We should at any rate be careful, with this example before us, to forecast the future as accurately as we can, and to endeavour to secure and maintain our superiority on the seas, rather by the skilful and immediate appropriation of every modern improvement in our material of war, than by the mere multiplication of the numbers of our ships.

The late Controller of the Navy has, in my opinion, laid the English Navy under a lasting obligation for the boldness of policy in this respect which he inaugurated. He never hesitated to accept responsibility, and to risk failure when some new mode or device gave reason to hope that its adoption would add power to, or increase the efficiency of the Navy. There were doubtless some failures in the ten years of his rule, but I think no one can deny, that that period has been marked by an amount of success in novel and grand enterprises in naval construction, which is without a parallel in our history.

"*Warrior*."

The first sea-going ironclad, the "Warrior," weighs, when complete, half as much again as the "Howe," and cost half as much again; her total cost, exclusive of ordnance and ordnance stores, being about £376,000. She carried when last commissioned, 32 guns, of which 28 were of 6½ tons, and 4 were of 9 tons. The number of her crew was 709 men, as compared with 1130 in the "Howe."

During the ten years which have passed away since the "Warrior" was completed, the power of armour-piercing guns has increased so greatly, that the 4½-inch plates with which she is covered through the middle of her length, can hardly be regarded as armour. Her plated side would be pierced by the 12-ton gun at 2,000 yards, by the 18-ton gun at 4,600 yards, and by the 35-ton gun at five miles!

"*Minotaur*."

There was a defect, however, in the design of the "Warrior," and also in that of the smaller but similar ships, the "Defence" and "Resistance," for which no thickness of armour in the middle of the ship could compensate, viz.:—that the steering gear is unprotected by armour.

This was the special defect which led to the design of the "Minotaur," "Agincourt," and "Northumberland," in 1861.

In these ships it was sought to protect the hull throughout with armour of the same resisting power as that in the "Warrior," and "Defence" classes, preserving the speed of 14 knots at the measured mile. In effecting this, it was decided to increase the total weight of the ships by one-sixth, and to spend upon them £100,000 more money than the "Warrior" had cost.

These ships answered the expectations of the designers as fully as the "Warrior" had done; but they have never been held in much favour by sailors. One principal cause of this, is probably the unusual mode of masting, the sail being distributed upon five masts. This was done in deference to strongly expressed opinions of naval men; but it is unsightly and ineffective. They spread more sail than the "Warrior," the area of plain-sail in the "Warrior," being 23 times the immersed midship section, while in the "Minotaur," it is 24¼ times. The proportion of sail to weight of ship is the same in both cases. But as a matter of fact, no sail is ever spread upon the two-after of the five masts, and it is found that even under these circumstances, the ships carry considerable weather-helm. We are satisfied that no change in the disposition of the masts would remedy this evil, and it has therefore been decided to make no change in the mode of rig.

I should state that the "Northumberland" differs from her sisters in having the armour above the main deck omitted from the extremities, and confined to an enclosed battery somewhat less than half the length of the ship.

"*Hercules.*"

The ships of the "Minotaur" class, like the "Warrior," may be pierced by the 12-ton gun at 2,000 yards, but the next ship to be considered, the "Hercules," is impenetrable to this gun at all ranges; and also, along the belt amid ships, to the 18-ton gun, at ranges beyond about 250 yards. Comparing her with the "Minotaur," it may be said that for £100,000 less money, or for the same cost as the "Warrior," a ship is produced throwing ⅛th more metal from the broadside than the "Minotaur;" having armour of more than double the resisting power; running at the same speed; and turning completely round in half the time. The drawback in this ship, as compared with her predecessors, is that whereas the "Minotaur" is propelled at full speed with 6,700 horse-power, the "Hercules" requires 8,500 horse-power to propel her at full speed. The speed is obtained in the former ships by fineness of proportion and form, and in the later ships, by high engine-power. It is to be remembered that this increase in power at full-speed does not represent a corresponding increase in the ordinary consumption of fuel, for in the first place the short ships are more manageable under sail, and require less steaming; and secondly, the ordinary working speeds are very low. The indicated power at these low speeds, say at 5 knots, would be, in "Minotaur" 562, and in "Hercules" 798, *i.e.*, the difference would be only 236 indicated horse-power at 5 knots speed.

As a matter of fact, the "Hercules" consumes much less fuel than the "Minotaur," because her engines are constructed on a better principle, the actual consumptions at 5 knots speed are, in "Minotaur," 4·28 lbs., and in "Hercules" 1·54 lbs. per indicated horse-power per hour. One ton of coal will carry the "Minotaur," 4·6 knots at 5 knots speed; while it will carry the "Hercules" 9 knots, or about twice as far.

"*Sultan.*"

The "Sultan" has the same bottom and the same thickness of armour as the "Hercules." But the arrangement of the armour above the main deck is altered. In the "Sultan," the main deck battery is lengthened 12 feet, and the after-embrasured and ports in it are abandoned as compared with the "Hercules." The armoured gun at the after-end of the main deck is also given up, and the after-fire is obtained from an armoured battery upon the upper deck, firing in a line with the keel. The armoured bow-fire is also changed, the single 12½-ton gun on the main deck of the "Hercules" being replaced by two 12½-ton guns on the upper deck.

While, therefore, the "Hercules" has ten protected guns, eight of 18 tons, and two of 12½ tons, together with four unprotected 6½-ton guns, the "Sultan" has 12 protected guns, viz., eight of 18 tons, and four of 12½ tons, and no unprotected guns, except of small calibre. The weight of broadside thrown by the "Hercules" from the guns named, is 1818 lbs., while in the "Sultan" it is 1965 lbs. The increase in the weight of the "Sultan" over the "Hercules" is 600 tons, part being in the form of armour in the upper part of the ship, and part in iron-cement between the two bottoms as a compensation for it. On the whole, the range of stability in the "Sultan" is even better than in the "Hercules," and her steadiness is nearly as great.

"*Monarch.*"

The "Monarch" is somewhat smaller than the "Hercules," her weight being 8322 tons as against 8677 tons in the "Hercules," and she cost as much money within £6000. The weights of hull in the two ships are within 100 tons of each other, and the weights of armour carried within 25 tons, but the armour in the "Monarch" is spread over a larger surface, and is therefore one inch thinner than in the "Hercules." The total weight of guns and ammunition carried, is in the "Hercules," 555 tons, and in the "Monarch," 478 tons, but the guns in the turrets of the "Monarch" are of 25 tons weight, while the heaviest guns carried by the "Hercules" are of 18 tons. The weight of broadside thrown by the "Hercules" is 1818 lbs., while in the "Monarch" it is 2600 lbs.

I will return to these two ships again after having described the next class, viz., the "Vanguard."

"*Vanguard*" *Class.*

These ships have both a main and an upper deck armoured battery, and command an absolutely all-round fire from 12 ton guns, protected by armour, while they are at the same time fully rigged.

There are properly six ships of this class, viz., the "Vanguard," "Audacious," Invincible," "Iron Duke," "Swiftsure," and "Triumph." The four first named are alike, but they differ in some important respects from the last two. Above the water-line, the ships are almost precisely alike, and the offensive and defensive powers are nearly identical; but the "Swiftsure" and "Triumph" have single lifting screws, while the other four ships have fixed "twin screws." For this reason the draft of water of the "Swiftsure" and "Triumph," has been made two feet more than that of the other ships, and to enable them to keep the seas as cruisers for longer periods than the others, their iron bottoms have been covered with a double wood sheathing, and over this a copper sheathing has been laid. Their armament consists of six 12-ton guns in the main-deck battery, and four of the same kind in the upper-deck battery. They also carry four 64-pounders unprotected.

It is very difficult to express by a co-efficient the several elements which constitute efficiency in a ship of war, but the principal elements of fighting-efficiency in a sea-going ironclad may, I think, be said to be—

1. The weight of armour per ton of ship's measurement.
2. The weight of the protected guns and ammunition carried.
3. The height of battery port sills above the load-water line.
4. The speed in knots at the measured mile.
5. Handiness and quickness in manœuvring.

A co-efficient of fighting efficiency may be constructed from these elements, if the following assumptions are made:—

First. That the efficiency will vary directly as the first three of these elements.

If an objection is made against the third on the ground that in a turret-ship, the guns have the advantage of being withdrawn further from the water in rolling by being placed centrally, and that this advantage is not shown, it may be answered, that neither is the advantage possessed by the broadside ship of having a greater number of guns, and that these advantages may be set off one against the other.

Secondly. That the efficiency will vary as the cube of the speed.

This power of the speed is taken because the differences in speed among the ships compared, are very small, but even small differences may have great results in an engagement.

Thirdly. That other things being the same, handiness and quickness in manœuvring will vary inversely as the length of the ship.

On these assumptions we get the following measures of fighting efficiency:—

Proposed approximate measure of fighting efficiency in fully-rigged ironclads, as given by the expression $\frac{A \times G \times H \times S^3}{L \times 100}$

A is the weight of armour per-ton of ship's measurement.
G is the weight of protected guns and ammunition.
H is the height of battery-port-sills above load-water line.
S is the speed in knots, at measured mile.
L is the length of ship.

	Tonnage.	Complete cost of Ship, and exclusive of Masts, Yards, Rigging, and Stores.	Measure of Fighting Efficiency.
		£	
Monarch	5102	345,540	149·8
Hercules	5234	360,147	113·4
Captain.....	4272	330,000	83·3
Vanguard.....	3774	255,000	83·0
Minotaur	6621	430,000	61·1
Warrior.....	6109	356,693	44·5
Defence.....	3720	223,055	10·9

The "Vanguard" class approaches nearest to the "Marengo" and "Ocean" class in the French Navy. But in the French ships, the guns in the upper battery are fought *en barbette*, and are dangerously exposed. Their armour also is so extended that, although they carry 1,280 tons of armour, as compared with 924 tons in the "Vanguard," and have 7·9 plates at the water line, the average thickness of the iron to be penetrated in the French ships is less than in the "Vanguard." The French ships weigh about 900 tons more than the English, but half of this is in weight of hull, where it adds nothing to fighting efficiency. There is also good reason to believe that the French ships are inferior in speed to the ships of the "Vanguard" class, and that the present nominal superiority in weight of broadside thrown, does not represent real superiority. Even on the assumption that the French 27 cm. gun has 1,150 feet initial velocity, which is believed to be greatly more than it has, and on the further assumption that the 24 cm. guns in the upper battery are protected as fully as those of the "Vanguard," which they clearly are not, we should have the following comparative energy per inch of shot's circumference in a broadside of the protected guns in each ship.

"Vanguard" 525
"Marengo"..... 430

It is to be remembered that of these French ships, "Ocean," "Marengo," "Suffren," "Friedland," "Richelieu," "Colbert," and "Trident," only one is of iron.

Before passing on to the unmasted ships, it may be as well to compare briefly the "Defence" and "Resistance," of 1861, with the 'Vanguard," of 1871.

The two classes cost practically the same for hull and engines; but on comparing them it will be seen that whereas, with a weight of hull of 3,730 tons, the "Resistance" class carries 607 tons of 4½-inch armour on 18 inches of wood, and a $\frac{5}{8}$-inch iron skin; the "Vanguard" class, with a weight of hull of 2,854 tons,* carries 924 tons of 8-inch and 6-inch armour on 12 inches of wood and on an 1¼-inch iron skin. In other words, with three-fourths of the weight of hull, there is an

* This weight includes the cement ballast.

increase of more than one-half in the armour carried. While the ends of the former class with all the steering gear are unprotected, the latter class are completely protected throughout the hull, and the upper and lower batteries.

The weight of the broadside thrown from protected guns is 1,250 lbs. for the former, and 640 lbs. for the latter. The speed of the two classes under steam is 13½ knots for the former, and 11¾ knots for the latter. The area of plain sail is 25,000 square feet in the "Vanguard" class, and 22,400 in the "Resistance" class.

To these facts is to be added the important consideration, that the former class has a double bottom throughout, and the latter for only a few feet on each side of the keel. It is to be observed further, in regard to handiness under steam, that the "Vanguard" class will turn completely round in 4½ minutes, and that the "Resistance" class require 7 minutes to complete a circle.

"*Devastation*" and "*Thunderer*."

The "Devastation" is the first sea-going ship of war,—properly so called,—designed without sails. The American ships "Monadnock" and "Miantonomoh" carried only a very limited supply of coal, and were never trusted at sea without an escort; but the "Devastation" class are expected to be able to maintain an independent existence at sea for long periods.

Comparing "Monarch" and "Devastation" as to power of endurance under steam, we consider that the average distance which the "Devastation" may be expected to run at 5 knots speed, with one ton of coal, is about 5¾ knots, so that her 1,600 tons of coal would carry her about 9,200 miles.

The distance which the "Monarch" would be carried under steam alone at 5-knots speed, by one ton of coal, would be about 6½ knots, and if under sail with sufficient steam power to keep the screw going (as is always done when the ship is with the fleet under sail) about 11 to 12 knots. Supposing her to have favouring winds, so that she may use her sail in this manner half her time, and to be under steam alone the other half, then it may be assumed that she would be carried about 9 knots on an average by one ton of coal, and her coal would then carry her 5,400 miles only, as against the 9,200 of the "Devastation."

On comparing the resisting power of the armour of the two ships, we see that while the total weight of the "Devastation," including all stores, is only one-ninth greater than that of the "Monarch," the weight of armour carried by the "Devastation" is just twice as great as that carried by the "Monarch." The side armour of the "Monarch" might be pierced by the guns of the "Devastation" at 2¾ miles, the charge being 115 lbs. of pebble powder, and the weight of shot 700 lbs. But the armour of the "Devastation" is not penetrable at all by the guns of the "Monarch" if R.L.G. powder is used, and is impenetrable with pebble powder (85 lbs.) at ranges beyond 200 yards. The 14-inch armour on the front of the turrets of the "Devastation" would be impenetrable to the guns of the "Monarch" at any range, but the front

turret armour of the "Monarch" would be penetrable at 2300 yards to the guns of the "Devastation."

I must not omit to state on the other side of the case, that the "Monarch" has two knots more speed than the "Devastation" is designed to have, so that while the "Monarch" could stand no chance with the "Devastation" in an engagement, she could always avoid one.

The chief difficulty to be apprehended in the ships of this class is the provision for a proper amount of light and air, as the ships will otherwise never be popular. I therefore attach very great importance to the superstructures recently added, by which we have been enabled to bring up all the ship's company and officers above the armour.

To compare the "Devastation" with the "Minotaur."

The hull of the "Minotaur" weighs more than her armour, armament, machinery, coals, and her whole equipment put together, while that of the "Devastation" weighs only half as much as her own. The armour of the "Minotaur" is equal to one-third of the weight of the hull which carries it, while that of the "Devastation" is ·83, *i.e.*, more than three-quarters of it.

The hull of the "Minotaur" is protected by $5\frac{1}{2}$ inches of armour, that of the "Devastation" by 12 inches. The weight of guns and ammunition in the two ships is the same, but the weight of a broadside of the "Devastation" is 2,400 lbs, while that of the "Minotaur" is 1,600 lbs.

The "Devastation" will be worked by a crew of from 250 to 300 men, while the "Minotaur" requires 700; and the cost of the two ships exclusive of ordnance, and ordnance stores, is about £320,000 for the "Devastation," and £478,000 for the "Minotaur," which is a difference of more than £150,000.

The question for the immediate future of the English Navy is, to what extent this class of heavily armoured unmasted ships, combined with unarmoured-masted ships, such as the "Inconstant" and "Raleigh"—which I am about to describe—will render ships of the mixed class, *i.e.*, with heavy armour and sails, undesirable. I shall not discuss that question, but describe briefly the "Inconstant" and "Raleigh."

"*Inconstant*" *and* "*Raleigh.*"

Both these classes are built of thin iron like an ordinary iron ship, they are then sheathed with wood, and the bottom is coppered. They have very high speed under steam, and sufficient sail power to enable them to cruize without any expenditure of fuel. The "Inconstant" attained a mean speed on the measured mile of $16\frac{1}{2}$ knots, and the "Raleigh" is expected to obtain 1 knot less. The armament of the "Inconstant" consists mainly of $12\frac{1}{2}$-ton guns, while that of the "Raleigh" will consist chiefly of 64-pounders. The "Blonde," which is of nearly the same design as the "Inconstant," will have mainly $6\frac{1}{2}$-ton guns and 64-pounders. The cost of the two types of ship—the "Inconstant" and "Raleigh"—will differ by about £40,000.

"Glatton" and "Cyclops."

I come now to the types of "coast defence ships," viz., the "Glatton" and "Cyclops" classes. The former has 12-inch armour on the sides, and carries two 25-ton guns, with a speed of 12 knots. The latter has 8-inch armour only, and carries four 18-ton guns, with a speed of 10 knots. The cost of the "Glatton" is within £50,000 of the cost of the "Vanguard," and exceeds the cost of the "Cyclops" by £70,000. The ships of the "Cyclops" class cost about £140,000 each for hull and engines complete.

I do not myself regard these classes as being such valuable additions to the English Navy as ships of the "Devastation," "Vanguard," and "Raleigh" classes would have been, and I am of opinion that when we are able to hold our hands in the production of such ships as those last named, and desire to organize "special coast defence," it can be done far more efficiently and cheaply than by an increase in the number of such ships as the "Glatton" and "Cyclops," excellent and powerful as they are. I consider that the "Cyclops" is nearly perfect as a ship of the particular type desired; and when the superstructures are added, they may be safely navigated to any part of the world. But, when designing for "coast and harbour defence" comes to be fairly considered, I am quite sure that the problem admits of an easy and comparatively inexpensive solution.

In all these cases I have called attention especially to the cost of the ships, because this is daily becoming of more importance. In modern marine warfare there are three modes of attack which are of a far more fatal character than any to which ships of war were formerly exposed, and a successful attack by either mode will probably lead to the foundering of the ship. The modes of attack to which I refer are, the "submarine gun," the "torpedo," and the "ram." And it is to be observed that the large and heavily-armoured ship is absolutely inferior to the smaller and weaker ship with regard to the attack of torpedoes and rams. The very hugeness and weight of the ships make them the easier prey to an enemy who attacks them below the armour.

From the under side of the armour belt, *i.e.*, from six feet under water to the keel, the ship costing £500,000 is as weak as the ship costing only £100,000; and she is more exposed to attack. So long as this is so, the most efficient ship is that, which on the smallest dimensions, will carry into action at a 13 or 14 knot-speed, guns capable of penetrating all but the exceptional armour of the ships of Foreign Powers, and protected by armour, proof to all but the exceptional guns of those Powers. It is in this aspect that the "Vanguard" class commends itself to my judgment.

If it should have appeared to you that I have expressed views not very favourable to some of the designs, I must ask you to remember that I do not appear before you as the rival of the designer in any of these cases. I have assisted in the production of every one of the ships I have described. I find that the original sheer drawings of the "Howe" and of the "Bulwark" class were made by my hands, and I have been more or less intimately connected with every subsequent

design. I have therefore felt myself at liberty to criticise them all freely for your benefit.

I would call attention also to the fact that while I have pointed out the irresistible power of the "Devastation" as compared with the "Monarch" and "Hercules," the comparison would be still more to the disadvantage of the ships of Foreign Powers. I have pointed out for example that the most powerful ships in the French Navy, the "Ocean" and "Marengo" are inferior in fighting efficiency to the "Vanguard," and are therefore greatly inferior to the "Monarch," "Sultan," and "Hercules." Of these three last-named ships, Mr. Reed and Sir Spencer Robinson may be justly proud; and if there were no limit to our wealth of men and money, we could hardly imagine better types for the cruising ships of the English Navy; but as there is a limit to both, I have made it my business to consider how we can get most money's worth for our money, under all the possibilities of future European warfare on the seas. For this reason I have extolled, and I think justly, the "Vanguard" class for "rigged ironclads." I have also shown to what a large extent the abandonment of rigging increases the power and reduces the cost of "armour-clads," and I think you will agree with me that we ought to look to the sea trials of the "Devastation," which will come off—if all goes well—in the ensuing summer, with the greatest possible interest. I hope to have the opportunity myself of watching her behaviour in the open seas in bad weather, and I may have the pleasure of reporting her complete success to you here before the year 1872 is ended.

Explanation of Diagrams.

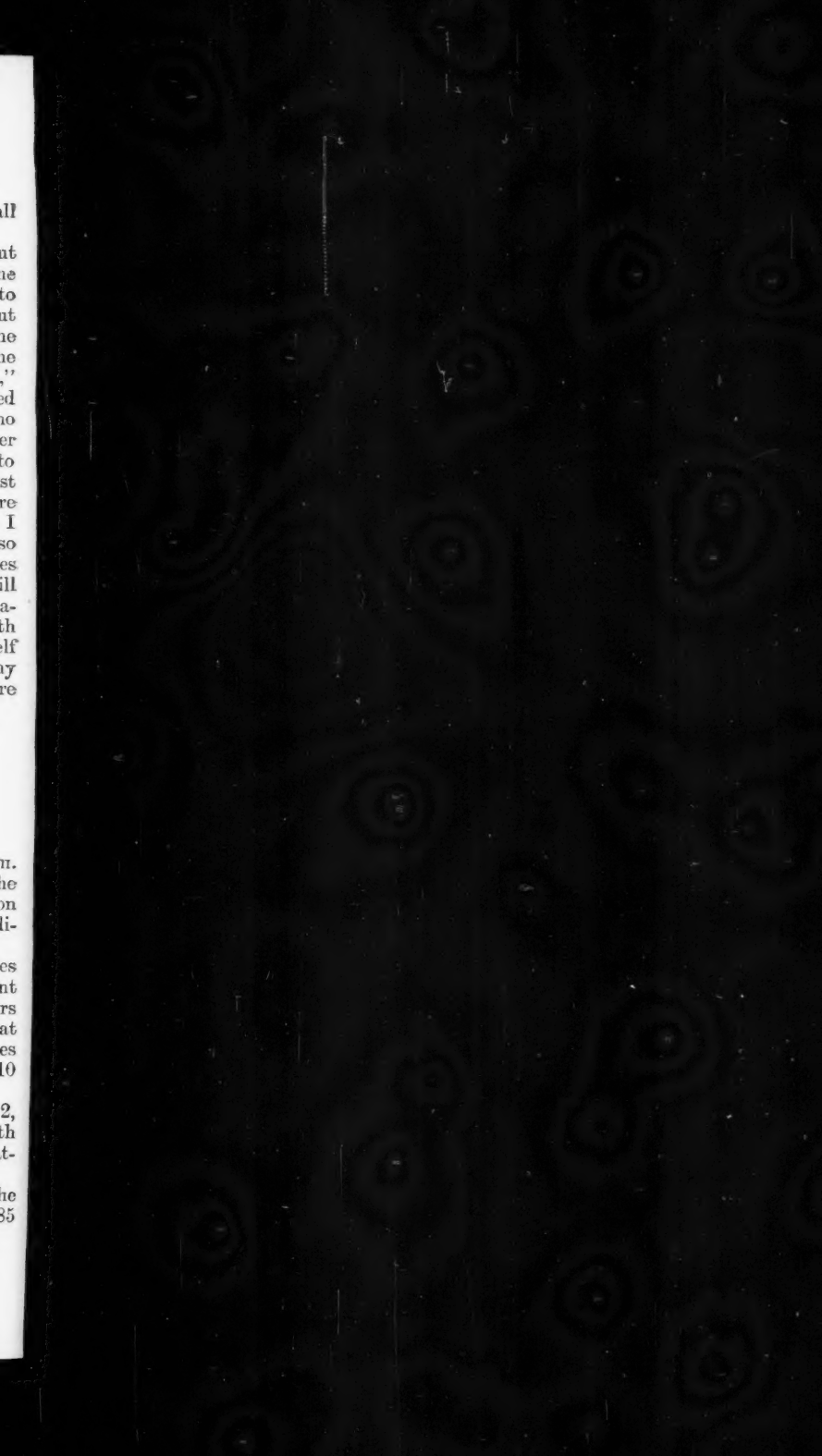
Armour and Gun Diagrams.

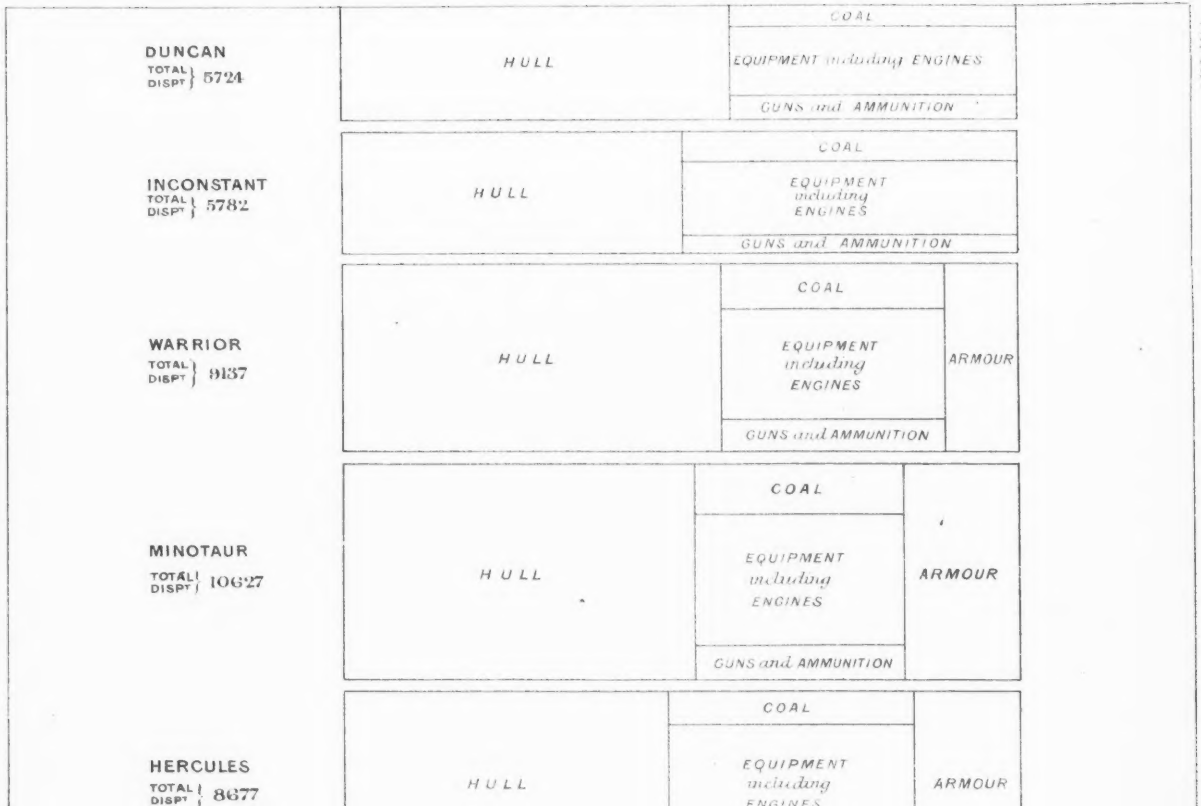
These must be understood to have no other authority than my own. They have been prepared for my own use from the records of the Shoeburyness experiments, and are as accurate as careful collation of experimental results, and calculations founded thereon by the ordinary formulæ can make them.

Fig. 1 (Plate III). Represents the resisting power of armour plates of various thicknesses up to 18 inches. It is in general agreement with the results of all experiments made up to this date, and appears to confirm the impression entertained by many gunnery Officers that for thicknesses up to about 7 inches the resistance of a plate varies with the square of its thickness; and that for thicknesses above 10 inches, the resistance varies directly as the thickness.

Fig. 2. Represents the penetrating powers at various ranges of the 12, 18, 25, and 35-ton guns, against armour backed as in Fig. 1, viz., with 10 inches of wood between longitudinal girders, 1½ inches of skin plating, and frames 2 feet apart.

A represents the 12-ton gun with 43 lbs. of R.L.G. powder: B the 18-ton gun with 60 lbs. of R.L.G. powder: C the 25-ton gun with 85




DUNCAN
TOTAL DISPT 5724
HULL
COAL
EQUIPMENT including ENGINES
GUNS and AMMUNITION
INCONSTANT
TOTAL DISPT 5782
HULL
COAL
EQUIPMENT including ENGINES
GUNS and AMMUNITION
WARRIOR
TOTAL DISPT 9137
HULL
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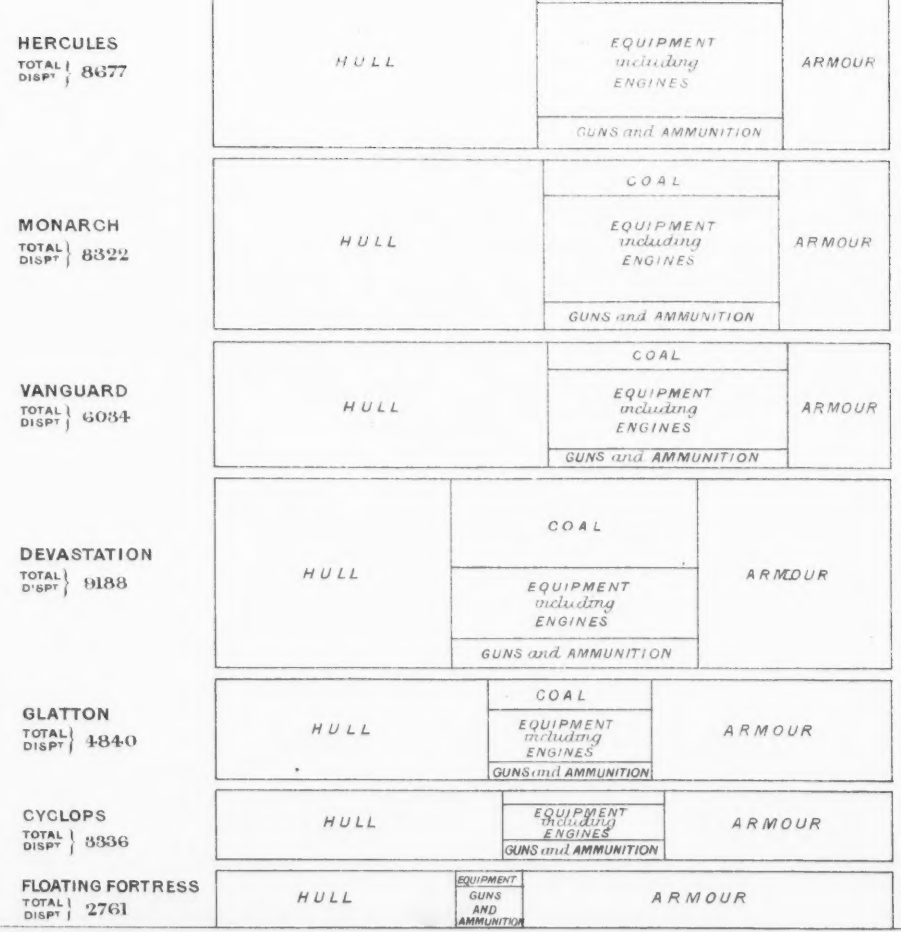
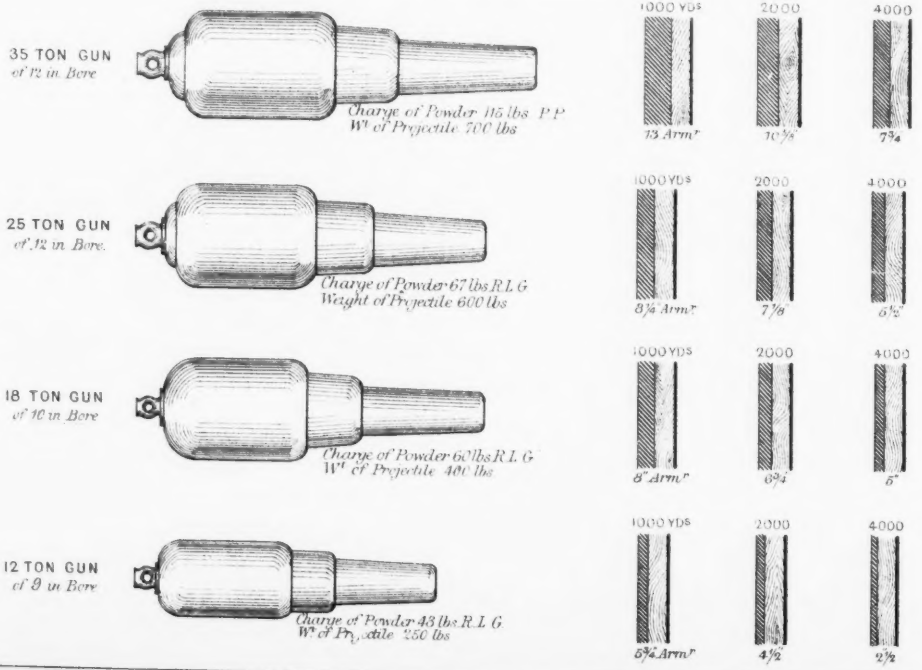
EQUIPMENT including ENGINES
ARMOUR


HERCULES
TOTAL DISPT 8677
HULL
EQUIPMENT including ENGINES
GUNS and AMMUNITION
ARMOUR
MONARCH
TOTAL DISPT 8322
HULL
COAL
EQUIPMENT including ENGINES
GUNS and AMMUNITION
ARMOUR
VANGUARD
TOTAL DISPT 6034
HULL
COAL
EQUIPMENT including ENGINES
GUNS and AMMUNITION
ARMOUR
DEVASTATION
TOTAL D'SPT 9188
HULL
COAL
EQUIPMENT including ENGINES
GUNS and AMMUNITION
ARMOUR
GLATTON
TOTAL DISPT 4840
HULL
COAL
EQUIPMENT including ENGINES
GUNS and AMMUNITION
ARMOUR
CYCLOPS
TOTAL DISPT 3336
HULL
EQUIPMENT including ENGINES
GUNS and AMMUNITION
ARMOUR
FLOATING FORTRESS
TOTAL DISPT 2761
HULL
EQUIPMENT GUNS AND AMMUNITION
ARMOUR

J. Stubbs

Pl V


35 TON GUN
of 12 in Bore
Charge of Powder 115 lbs P P
Wt of Projectile 700 lbs
1000 YDS
2000
4000
13 Armr
10 1/2"
7 3/4
25 TON GUN
of 12 in Bore.
Charge of Powder 67 lbs R L G
Weight of Projectile 600 lbs
1000 YDS
2000
4000
8 1/4 Armr
7 1/8
6 1/2
18 TON GUN
of 10 in Bore
Charge of Powder 60 lbs R L G
Wt of Projectile 400 lbs
1000 YDS
2000
4000
8" Armr
6 3/4
6"
12 TON GUN
of 9 in Bore
Charge of Powder 43 lbs R L G
Wt of Projectile 250 lbs
1000 YDS
2000
4000
5 3/4 Armr
4 1/2
2 1/2

J. Hobbins

| | | |

Fig. 1

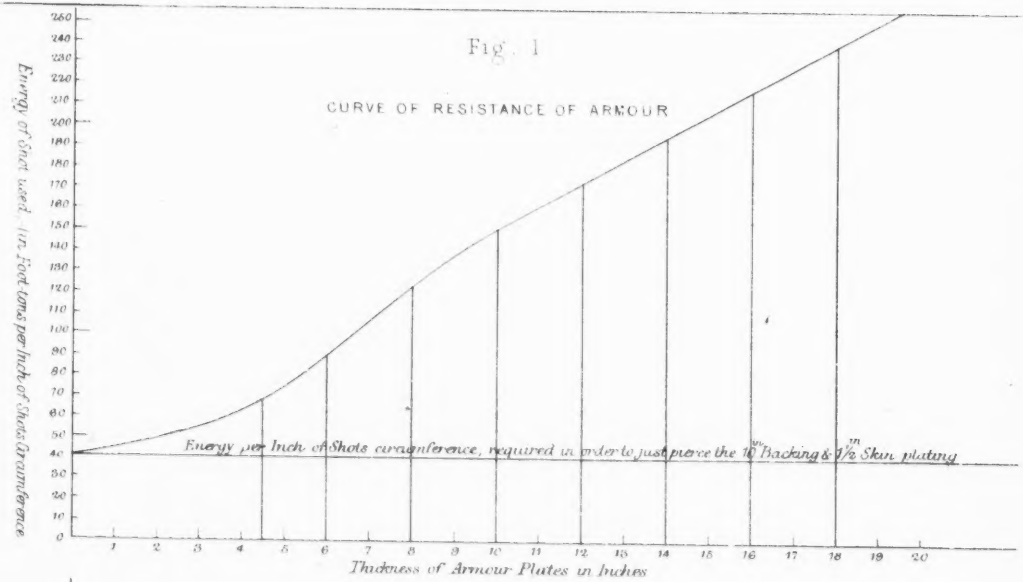
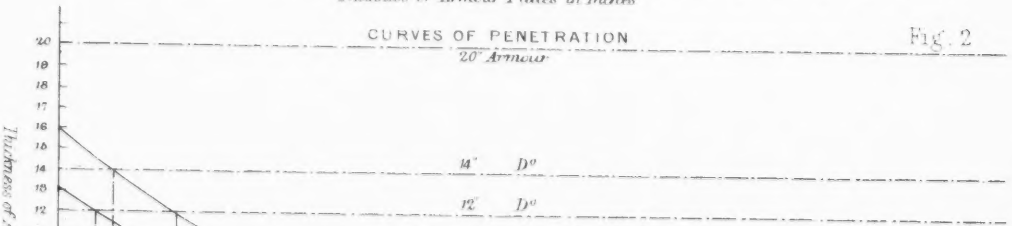

CURVE OF RESISTANCE OF ARMOUR
Energy of Shot used. in Foot tons per Inch of Shots Circumference
Energy per Inch of Shots circumference, required in order to just pierce the 10" Backing & 1" Skin plating
Thickness of Armour Plates in Inches

Fig. 2


CURVES OF PENETRATION
20" Armour
14" D°
12" D°
Thickness of

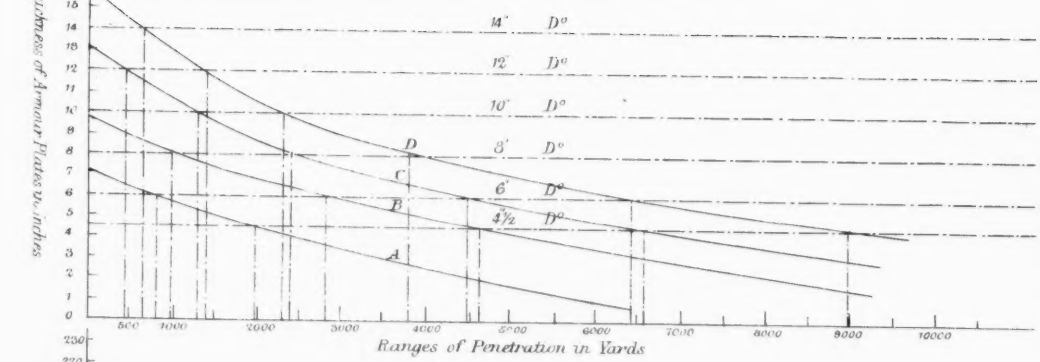
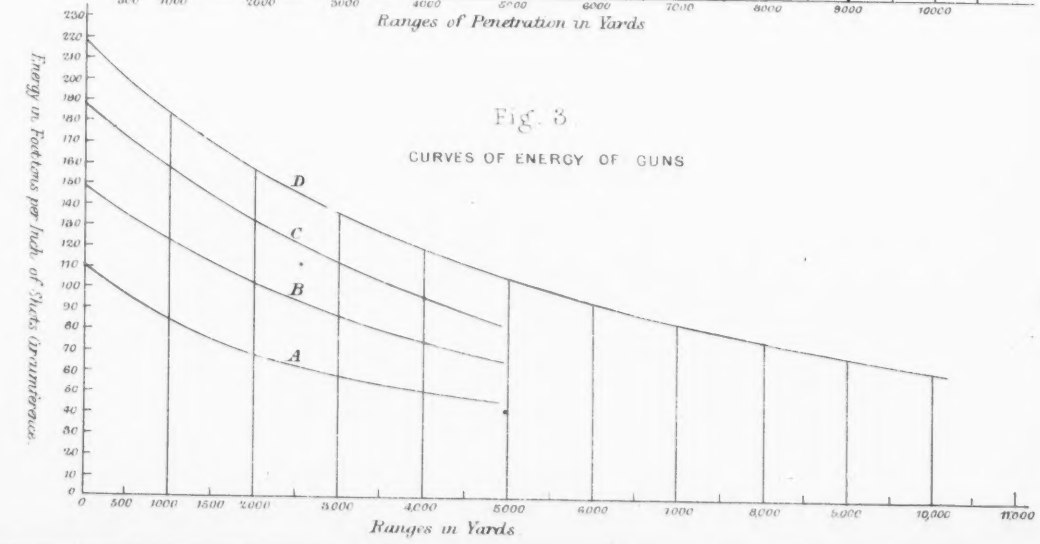


Fig. 3

CURVES OF ENERGY OF GUNS


Energy in Foot tons per Inch of Shot's Circumference
D
C
B
A
0 500 1000 1500 2000 3000 4000 5000 6000 7000 8000 9000 10,000 11000
Ranges in Yards

Pl III

lbs. of pebble powder: and D the 35-ton gun with 115 lbs. of pebble powder.

Fig. 3. Represents the energies of these same guns at various ranges.

It will be seen that by means of Fig. 1, it can be readily ascertained what thickness of armour a shot of known weight, diameter, and velocity from any gun will penetrate, the energy of the shot in foot-tons per inch of circumference being $\frac{Wv^2}{2gc}$ where W is the weight of the shot in lbs., v its striking velocity in feet per second, g is 32·2, and c is the circumference of the shot in inches.

By means of Fig. 2, the ranges at which the principal English guns will penetrate armour, backed as supposed, can be ascertained; but it is to be observed that the wooden ironclads of France and other countries have nothing corresponding to the $1\frac{1}{2}$ inches of skin-plating, and their resisting power must be reduced on this account.

Fig. 3. Furnishes the means of ascertaining the penetrative power of the guns named at various ranges, against other arrangements of armour than that supposed, a curve similar to Fig. 1 being constructed from the result of experiments with guns of known energy, against such differently formed targets.

The diagram (Plate IV) representing the heavy guns themselves shows the armour which can be just perforated by these guns, at the several ranges named, under the conditions given above.

Displacement Diagrams.

These diagrams (Plate V) furnish a graphic representation of the comparative weights of the completed ships, the areas of the rectangles being in all cases in proportion to the entire weight or displacement.

All the diagrams are made of the same length in order to show clearly the variation in the proportions of weight of armour, equipment, and hull, to the entire displacement in the several ships. The smaller rectangles into which the principal one is divided, are in exact proportion to the weights of the parts named.

Captain WHEATLEY, R.N.: We had a very interesting paper the other evening from Captain Colomb on "the Attack and Defence of Fleets," and we also had a very good speech from a young officer (Lieutenant Grenfell), who was one of a party of officers who have formed an Association at Portsmouth to discuss naval subjects. In Captain Colomb's paper it was very clear that the attack must, in all circumstances, whether the line be formed "head and stern" or "abreast" be made "end-on." The question was asked—In case of meeting an enemy's fleet, say the Russian fleet, which has a torpedo on each side of every ship, how is that fleet to be attacked? There was no answer. That same young officer stated that, when falling in with our fleet of evolution, the question arose among his shipmates—Supposing that is an enemy's squadron, how are they to be attacked? There was no answer. It appears from this, that guns on the broadside are comparatively of very little use, and as the attack must be "end-on," it requires a powerful battery both ahead and astern. I had the honour of bringing forward last April a different form of ship from any that has been produced here;

not a very new form, because it is founded on perhaps the oldest form of sea-going ships, the ships of the East. But to have a very heavy battery ahead and astern, you must increase the beam, and the beam can be increased in certain proportions without decreasing the speed. Now, an enemy's fleet at sea unopposed,—as we are in our island, which does not afford sufficient subsistence for the population,—would be more fatal to us than a landing on our shores. Our commerce is our life, we cannot do without it. The ship that I proposed brings eight 35-ton guns to fire in line with the keel either ahead or astern. She has also a projecting bow. She would be able to bring a torpedo against another ship sooner than a ship of any other form could bring one against her, and that is the only solution of the question, the question of two ships meeting, which shall first bring her torpedo to strike against the other? Now, the sloping bow with an outrigged torpedo along its upper slope which would project forty or fifty feet beyond the bow, and be about eight or ten feet under water, would give the torpedo its greatest power. The projecting beak being only from 8 ft. 6 in. to 7 ft. 6 in. above water, would tow a Harvey torpedo on each side with only three or less than four fathoms of tow line. Any other form would require from forty to fifty fathoms to bring it to bear under water. Therefore, I think that the form deserves a little more consideration than it has yet met with. I should like to add a few words about the loss of gun power in our ships. I saw in the newspapers that an American Rodman gun of 35 tons had been landed at Constantinople. This, of course, is a smooth bore. They have not yet adopted the rifled gun, and I think, however well the rifled gun may answer on shore, we have a great loss in not keeping to the smooth-bore at sea. I was not in the service when we had a war with the Danes in 1811 and 1812, but I have been with officers who were employed there. They said the gunboats always engaged beyond point-blank range, and when they saw a shot come splashing along the water, they were sure they were going to be hit. With the rifled gun, where the range is undergoing constant change, you cannot make sure of a hit; but with the ricochet which you have with the smooth-bore shot you are pretty sure to hit. Thus you lose by the rifled gun. Another loss you have. Unarmoured ships have been talked of for rams and torpedoes. By loading these large guns with grape, you increase the chances of hitting eight-fold; and one single shot penetrating the engine would disable any unarmoured or light-armoured ship, whether torpedo or ram. *

Commander W. Dawson, R.N.: I think we ought to congratulate Mr. Barnaby on the exceedingly valuable paper which he has brought before us, and the exceedingly candid way in which he has discussed and criticised very fairly what may be called his own productions, being those of the Admiralty during the last ten years. I am sure that anybody who will examine the new ships at the outports, will be struck with the extreme ingenuity which characterises all their different parts, and the many and great novelties that have been introduced. They reflect the greatest credit on the Constructive Department of the Admiralty. I say so most unreservedly, though I am not usually an indiscriminating admirer of every new thing I see, but am, generally, inclined to criticise very sharply those things that do not agree with my own notions. Mr. Barnaby has also brought before us some information on points which it is exceedingly difficult for a naval man to get acquainted with, such as the ruling principles which have guided the authorities in putting certain classes of ships into our hands. It is important that we should know what are the intentions of their constructors, if we would gather some idea of the best use to which these ships are expected to be put, and how we are supposed to employ them. For unless we can obtain such information as to the aims of those who constructed them, as Mr. Barnaby has given us, we really have not the basis to go upon in deciding the principles on which all future naval tactics should be based, or naval battles be fought. There are some controversial points connected with these ships that I confess I should like to have some little information upon. I merely allude to it now, not to raise a controversy, but in order that Mr. Barnaby

* I did not mention it in the remarks I made as above, but I take it that a 35-ton smooth bore could have a bore of 18 inches diameter, and throw a solid shot of 800 lbs. As grape, a cluster of 12 50-lb. shot, with bar and disc, would weigh over 600 lbs.

may explain to us the view which the Constructive Department take of points that have been often discussed elsewhere. One difficulty is about putting "ballast" and "cement" in the bottom of ships of the "Vanguard" class. Why was not the additional weight put in in the shape of thicker iron plates, which would add to their strength, instead of "cement" ballast? He understands the controversy. I do not wish to enter into it, but only ask for information. The armament of the "Vanguard" class is far below modern requirements, and seems based on the fallacy that their own armour, and not that of the enemy, should govern the power of their guns. They ought to carry 18-ton guns. There are some of these classes of ships that I dislike very much; one is this modern low freeboard class for coast defence. What on earth do "coast defence" ships mean? In criticising these low freeboard ships, I am not criticising the Constructive Department of the Navy, which is simply the servant of the Board of Admiralty for the time being, obeying the orders it receives from its superiors. A former Board of Admiralty, whose members are deservedly held in high esteem, ordered these "coast defence" ships to be built. One of their number, an officer whom we all respect, whose opinion I hold in the highest estimation, told us in a letter to the *Times*, that the Constructive Department were ordered to construct ships that could be easily run over in mid-ocean, which could not possibly float in shallow water, that could not go from one port to another except after careful study of the barometer, that could go to the bottom readily in a very heavy sea-way, and in a variety of other ways, and that possessed the smallest amount of offensive power, and the maximum amount of defensive power against artillery. That problem the Constructive Department of the Admiralty have solved very faithfully and exceedingly cleverly, in giving us "coast defence" ships which cannot defend the coasts, and "harbour defence ships" which cannot move about our harbours. If they came across a lumbering merchant-ship at night, keeping a bad look-out, it is very likely they would be run over, and would go to the bottom. As to what would occur in a naval action, when hostile ships tried to run over them, is easily conjectured. Hostile ships would either overturn them, or else they would run up one side of them and send them down. I have got some recollection of serving in small craft in the Chops of the Channel in my younger days; and at night, in anything like a breeze or a sea-way, we always loaded our largest gun with a heavy charge, in order to frighten any merchant-ship that we feared might run over us. The same thing might happen to the "Glatton," the "Cyclops," and vessels of that class. If they cannot venture with safety into open water, I do not know what purpose of war they are meant to serve. They draw too much water for harbour defence, and if there was water enough for them in the harbour, high-sided ships could follow them, and instead of defending the harbour, they would have to look out to prevent themselves being run over. Now, an unarmoured vessel, a gunboat, would carry the same weight of guns that either the "Glatton" or the "Cyclops" carries, and yet be of small tonnage; probably a vessel of 400 tons would carry either ship's armament, and would draw very few feet of water. Such a gun-vessel would be able to go into shallow waters, and get out of the way of bigger ships, and would not be able to go to the bottom when at sea by being unseaworthy. I must protest most strongly against unseaworthy ships being wilfully designed. The British Navy has no place for an unseaworthy ship. A ship that would be likely to go to the bottom in sight of land because of the barometer falling, ought not to be built at all. We had an example a few years ago of one small ironclad being sent from Plymouth to Cork, and being compelled to put back; the Commander reported that it was only by a "merciful interposition of Providence" that ship and crew did not go to the bottom. I say it is morally, politically, and professionally wrong to put men into a ship that cannot go from Plymouth to Cork without the risk of going to the bottom. Whatever the size or denomination of our ships, they ought to be, before all things, perfectly seaworthy; and if they are fit to go from Plymouth to Cork, they would be safe to go anywhere else. That is the only class of vessel against which I wish to protest in strongest condemnation. They are neither seaworthy ships, fit to take part in a general action, nor are they safe enough for coast defence ships, nor is their draught of water suitable for harbour defence. We do not want ships to go up and down the Medway, the Tamar, or the Thames; that is not the purpose for which England

wants war ships. As to the "Devastation," she is not half built yet, and I have not seen the drawings, so that I am unable to form an opinion as to this novelty in naval designs. I reserve my views upon that class until I am better informed as to their construction and qualities. Then, in the new designs, I notice also that there seems to be no provision for the use of the torpedo, though that weapon has been adopted in the Service for several years. We have made provision for using the "ram," but we have not recognised that the torpedo has been adopted in the Navy for the last three or four years, and that the best defence against hostile torpedo-ships or rams, is the employment of that weapon also. No provision has been made for employing torpedoes as a means of defence. Every class of ship should be able to make use of the torpedo, as her best defence against naval torpedoes and rams; provision for the safe handling of this defensive weapon might easily be made without adding to the weight of the ship.

Capt. HOSEASON, R.N.: I am sure we are excessively indebted to Mr. Barnaby for bringing this important subject before us; it is, however, perfectly impossible to express an opinion upon so valuable a paper on hearing it read for the first time. I shall, therefore, content myself with making one or two observations. Mr. Barnaby observed that we continued to build wooden ships long after the properties of iron ships were well known, this is a fact, but the true cause Mr. Barnaby has not even hinted at, viz., that the "Megæra" and "Simoom," ordered to be built in 1843 or 1841, were intended for men of war; in the course of their construction, the necessity for a more searching test as to the applicability of iron to the purposes of war, was suggested to the then First Naval Lord of the Admiralty, and that the experiment should be tried against the section of a strong riveted side of a steamer, to create as much concussion as possible. A target of this nature was constructed, and the Board of Admiralty went to Woolwich to witness the experiment; the first shot fired, shivered the target to pieces, a splinter wounding a sentry two hundred yards distant. This important experiment passed off at the time quietly, and the "Megæra" and the "Simoom" were converted into "transports;" this formed the nucleus of the present very inefficient "transport-fleet." In 1849, or five years after, a hue and cry was raised by the late Admiral Sir Charles Napier and Admiral Sir Maurice Berkeley, in Parliament, against the previous Government, for having constructed vessels of iron, and elaborate experiments were carried out against iron targets at Portsmouth on board the "Excellent." These experiments threw no new light on the question, but left it in the same position, as after the Woolwich experiments in 1844. Thus, to serve a political purpose, the best interests of the country were sacrificed, and the introduction of iron for the purposes of naval construction was retarded for years, as has been stated by Mr. Barnaby.

It is impossible to accept the formula Mr. Barnaby shows on the board as a correct measure of the relative efficiency of the ships he has compared; mathematics are only a symbolic manner of reasoning, and as in logic, if false premises be advanced, false conclusions are arrived at, so any incorrect factors in such a computation are sure to lead to error. I object to the velocities stated, and to the source from which they have been obtained, and I contend that when thus cubed and introduced into the formula, they will never give a correct relative measure of the efficiency of the ships.

Captain COLOMB, R.N.: I merely wish to add one word to say to Mr. Barnaby what he no doubt has observed, that his paper has not been very closely criticised. I have noticed in this theatre that the more exhaustive and the more complete the papers are, the more the meeting is in agreement with the lecturer's views, the less is the discussion, and the less is it to the point. I think Mr. Barnaby must take it that the naval members present are generally in accord with the views he has expressed. The navy owes a debt of gratitude to him for coming forward in this way, and for giving us information which, I for one, have never before seen in such complete form as I see it before me now. It is information of a kind which I have been anxious to get, which I have written to Shoeburyness for, and which I have tried in many ways to collect, and have been unable to do so. I was not aware that Mr. Barnaby had it all in his own head, or I should certainly have come to him for it. I have only risen to offer my very sincere congratulations to him, and to thank him for the lecture he has given us.

Captain FREMANTLE, R.N.: I think it is quite clear that we have had a very able, instructive, and suggestive lecture. We come here to improve upon the suggestions that are made to us. Some very valuable suggestions have been placed before us, and it is a great pity that we have not confined ourselves a little more to the point, or endeavoured to improve upon the suggestions thrown out. There was one suggestion of great importance as to the proper size of our ships, and the way in which they should be defended against torpedoes. That is one point. There is no time to do more than allude to these subjects, but in any case I could wish that other gentlemen who are better versed in such matters would undertake the task rather than myself. I merely allude to these points in passing, and would fain hope that they may be subjects of thought to us in future. Another question of great importance which Mr. Barnaby placed before us, and although he said he would not deal with it, yet he certainly gave us an insight into what his own opinion was as to whether it is advisable to have what we may call composite ships, ships built to carry very heavy armour, and to go at great speed, and at the same time to have masts and sails; whether, in fact, we can combine what used to be understood as "full-sail-power" with a large amount of armour. Now these are suggestive subjects, and I confess it appears to me that Mr. Barnaby is right when he seems to consider that the "Devastation" class, and ships of that sort which are built entirely for steam, without any sail power, are likely to supersede the composite ships of the "Monarch" and "Hercules" class. Another important subject on which he touched was the question of cement in the bottom of ships. Captain Dawson referred very properly to it as to whether we could not replace that cement, which I understand in the "Sultan" amounts to about 495 tons, by something in the shape of armour-plating, which might be sufficient to have some effect, at all events in resisting the impact of the torpedo. These are some of the subjects which Mr. Barnaby did touch upon. There are some which no doubt he was obliged to leave out. They probably would have involved too much discussion, and one cannot be astonished that he did not choose to deal with them. One of these is the question of stability. It has been dealt with before in this theatre, but it would have been of importance and rather satisfactory if Mr. Barnaby could have displayed something like the curve of stability of those ships. We see the great advance which has been made between the "Defence" and the "Captain," as far as fighting power is concerned. We see that the co-efficient of one is represented by 10·9, and of the other by 83·3. We know the "Captain" went to the bottom, and we know the "Defence" has not done so. That appears to me to be a very important point, but I am not prepared to say that anything like stability could have been added to that formula to make up those figures which he has given us on the board. However, it is decidedly an important point, and as an important point, it is a pity the time does not allow of its being dealt with at all. There is another thing which is not alluded to by Mr. Barnaby, which is also a subject of great importance. It is noticed by Mr. Reed in his "Iron-clad ships," that is, we want, very much, further experiments with the torpedo. Mr. Reed tells us that he has built his ships with double bottoms and with water-tight compartments, on purpose that they might resist the attack of these infernal machines. But he has told us at the same time, that no experiments have been made as a test in the slightest degree. We understood some little time ago that an old iron steamer had a double bottom given her, with the view of testing this question, when it was discovered by somebody that the line of least resistance would be taken by the explosive, therefore the whole of her double bottom was likely to be blown out, and that as a test the experiment would be useless, and nothing has been done in this direction. There is one other subject I should like to allude to, which Mr. Barnaby did not touch upon, that is the question of the number of guns. We all know that the number of guns has a great deal to do with the power of a ship. It has been pointed out by Mr. Reed in his "Iron-clad ships," in a little figure which he gives us, the advantage which the "Hercules" will have with a considerable number of small guns over a ship like the "Monarch," or "Captain," with a few large guns. That is a point which was dealt with by Captain Colomb last year. It is a question whether that could not have added to the formula as part of the co-efficients, for it is clearly an important point in calculating the power of ships.

Captain SELWYN, R.N.: I am going to ask for a few minutes, not to carp at, or

indeed to do anything else than praise the most lucid and able manner in which this lecture has been brought before us. But there are some points on which I think that a free discussion in this theatre may strengthen rather than weaken the hands of those who have the power of carrying useful improvements into effect, and to those I should wish principally to advert. I am delighted to see that to the speed has been given a very high function in that mathematical equation which, however it may be deficient in some of its parts, is probably the nearest thing we have yet had to some measure of each ship's efficiency. I understood Mr. Barnaby only to mean it in that direction; it was something by way of giving us an idea of the comparative efficiency of vessels. But I feel, and Mr. Barnaby feels, as strongly as I do, for I have talked with him on the subject, that we have a power now thoroughly carried out and proved, and I believe proved for the first time, in one or two of the latest coast defence vessels that will materially increase the speed, provided that we cease to be afraid of attaining a little increased pressure in our boilers, which is, in fact, the foundation of the success of what are known as "compound engines." I have crossed the Atlantic twice within the last six months in one of the national line of steamboats, a vessel which would formerly have used something like thirty tons of coal per day, and which now uses less than fourteen tons, simply from the adoption of the "compound engines." It is quite possible to do that in the whole Navy. It has been done in some few vessels, and I hope to see it thoroughly carried out. Then the questions which relate to the ignoring of sails and the adoption of steam alone in those vessels of a certain class, which are only intended to defend our shores, will receive a very great simplification. We shall not be afraid then to trust to the steam power we carry, and to use it alone and entirely. We shall not attempt to combine a form which is really unfitted for shallow waters with a superstructure like that of the breastwork monitor, of which I can only say that it appears to have been built up by a succession of afterthoughts, in which it is even at last necessary for the safety of the vessels that they should have an afterthought of outside skin, to prevent the inside portion being immersed too deeply for safety. We shall not then any longer hesitate in defining our classes of vessels distinctly. For all purposes of coast defence there are two useful classes of vessels—a light boat, which may carry one gun of extreme weight and extreme charge, steam launches so to call them, attached to a particular port, manned and used by the Naval Reserve men of each district, and by no other persons, thoroughly well known by them, capable of being called rapidly together from the different outports by telegraphic communication to any point of the shore threatened; and the "floating forts." We may well call them "floating forts," for that is the true definition of all vessels intended for coast defence, utterly and totally distinct from those vessels which are intended to carry on communication with distant shores to enforce the respect due to our flag, wherever that is carried, and which must not only be habitable, but pleasurable and healthy habitations at sea. Our sailors must be able at sea to take a pride in our vessels, and we must be prepared to defend our shores with the energy which belongs to our race. If we seek for speed, and speed alone, by means of large fuel expenditure, we shall possibly commit an error. But when we have got speed by means of improvements in steam, such as I have spoken of, when we are able to combine speed with what in horse racing is denominated "bottom," then we see our way towards giving up sails, except in very fair winds having a very small quantity of sails for that purpose, only using them when the wind is strong, and giving up all idea of beating to windward and bracing up the yards as a waste of time and money, because, however fond I am of my profession, I do say that nothing can stand against the test of utility. If you have to spend more money to produce a certain effect, then you must give up the idea of doing it in that way, however beautiful you may have learnt to consider it. Here I remark with great pleasure the enormous advantage which has been shown on that board, however the figures may be in error, because, although the figures used, do not give the actual speed at sea, yet it will be seen that the errors are proportionably applied to all, therefore the results are still exact. (The CHAIRMAN: They are merely comparative.) They are comparative numbers. There has been a remarkable advance, when from 109 efficiency, we can go up to 149·8, with a difference of only £100,000 in the cost, and 2,000 in the tonnage. It shows a very great advance,

but I should like to see that advance made in another direction. I should like to see an abandonment at once of all ideas by which the "floating fort" is calculated to be propelled by outside screws, and consequently to have deep draught of water, in favour of those plans which you had placed before you by the late Mr. Elder. I should like to see Captain Moncrieff's hydro-pneumatic arrangement for guns understood and appreciated, an arrangement by which the guns are carried low down in all weathers, by which they are thoroughly armoured, by which the armour can be placed where it is wanted, and not where it is of no importance. It matters nothing to us if the ship is pierced above the water line, you can easily close those holes when made, by simple applications, as long as the crew at their quarters are protected sufficiently. That is all we want. We do not want anything more than high coal-carrying power, great speed, which is to be obtained, I think, in these coast-defence vessels on the light draught given by the "elliptic section;" in the small launches, by the adoption of such improvements in the material of which they are built, and in their forms, as have been instanced most remarkably in a small vessel in which I had the pleasure of making a trip within the last few days, Mr. Thorneycroft's launch; she does nineteen miles an hour, with a draught of three feet. (The CHAIRMAN: She is made of steel.) She is of steel, or rather steel she will be called until people begin to understand that steel is really nothing but good iron; that is, all that steel is in the present day. I hope everything that may be said in this Institution on such occasions as these will be said with the view to strengthen the hands of those whose responsibilities are very great, who may not always judge rightly, but who, I am sure, if they would cordially unite with those who can give them information in this and other institutions, will go forward to great success; while jealousies on all sides can never lead to anything but trial of temper and disappointment.

Admiral of the Fleet Sir GEORGE SARTORIUS: I must commence by expressing my great satisfaction at the able manner in which Mr. Barnaby has treated the subject of his lecture. I must preface the remarks I am about to make by confessing that I know nothing of the science of shipbuilding. I claim only to be the practical sailor whose duty is to navigate and fight the ship. I always look upon the ship as a magnificent tool, manufactured by able, scientific makers, and then delivered over into the hands of the sailor as the skilful workman who is to make the best use of it for the purposes in view. As the manufacturer can never be practically acquainted with the innumerable and varied difficulties the workman is sure to meet and must overcome, the wise manufacturer should, previous to commencing the manufacture of his tool, search out and consult the ablest and most intelligent of the workmen who are to use the tool as to the nature of the work he has to perform, and his wants and requirements for an efficient manner of doing his work. When well informed upon these points, the manufacturer could hardly fail in manufacturing a very efficient tool. I am afraid the reverse of this mode of proceeding has been the case with the greater part, indeed I may say with almost all the new ships that have been constructed since the commencement of the actual transition state of the Navy. They appear to have been constructed upon the caprice and imagination of the constructors alone, beautiful objects of art and science, but very unfit to do the work required from them.

Naval warfare may be divided into three distinct classes. First, warfare on an enemy's coast; secondly, defensive warfare on our own coast; and, thirdly, ocean warfare.

As the first will be carried on generally in joint expedition with troops for such service, it is indispensable that the war vessels should be of moderate draught, very handy, very swift, able to turn very quickly and in very short spaces, and if with sails, to be perfectly manageable under canvas, in case of accidents to screw, from shot or rock. The war ships will have considerable risks to encounter in the unavoidable duties they have to perform, such as engaging batteries, covering the landing or embarkation of troops, chasing of enemy's vessels, and all which demand a very near approach to the shore or battery, and a rapid fire from their guns. The steam vessels would require a large capacity for stowing fuel.

For defensive coast warfare, the same qualities will be required, but with much less capacity for the stowage of fuel and less draught of water. Masts or sails will

not be necessary; perhaps peculiar types will be required for "*permanent defence* "*vessels.*"

Ocean Warfare. This class embraces equally those fitted for offensive coast warfare. As these vessels must be adapted at a moment's notice to go to any part of the world in pursuit of an enemy's squadron or fleet, they must have great speed and strength, and if with sail, be able to make six or seven knots on a wind with *sail alone*, and if without masts to be able to carry at least three weeks' full steaming, and should have double screws. They must also be good sea boats.

It is needless to say that none of the vessels actually constructed, can fulfil the conditions required from them as efficient for performing their duties in each of the three classes. They (particularly the larger ones) are too long, they make too large a curve on turning, they carry much too little fuel, and under sail are (the most of them) utterly helpless.

Now for the class of vessels I have been so long advocating, viz., the "ram." To speak of those actually constructed, they are, with many other faults, totally deficient in the most important requisite for the ram, viz., that of speed. What can the strongest man do if his enemy can always avoid his blows, and tease him with annoying attacks. Such a vessel may have the charge of a convoy of transports of troops or merchant vessels, and they are met by an enemy, ram or otherwise, but very rapid and handy; she could get in amongst the convoy and destroy half the vessels composing it without giving the slow and heavy protector the chance of getting a shot at the interloper. To use its prow, of course, is out of the question; and could such a ram escape destruction from the attack of two smaller but swifter rams? The efficient ram must have very great speed and great handiness. This is an important fact for us always to bear in mind. There is no nation or combination of nations that will be able to rival us for years to come as ship-builders or engine-makers, therefore there was no necessity for our building in a great hurry so many untried new models. I quite concur with the observations made by Mr. Barnaby at the commencement of the lecture that we ought to study closely, and carefully to obtain the best and most efficient forms and qualities, and not trouble ourselves in accumulating numbers. Should any other nation strike out a more perfect model than any yet produced, we should soon know it, and then construct upon that model, five improved models by the time the originator had completed his one. By keeping a good watch upon what other nations are doing we shall always be able to have a sufficient number of really effective vessels of every good type to prevent any mischief being done at home or to our external empire.

I hope that Mr. Barnaby's excellent example will be followed, and that there will be in future more frequent intercommunications between the manufacturers of the tools and the practical workmen who require them. The result would then be such as to throw great material credit upon both parties, and the country would be benefited.

Mr. BARNABY: I am very much obliged to you for the kind way in which you have received my paper to-night. I was asked to read a paper illustrative of your models, and I only appear here to-night in the character of showman of these models. Some of you have treated me more as if I represented the Lords of the Admiralty; but I do nothing of the kind. Doubtless there are gentlemen here who ought to be Lords of the Admiralty. If they were I think it very likely we should not get orders to build some kinds of ships that have been described to-night. But with that I have nothing to do, and I do not propose to answer any question with regard to them. I would say as to the 9,200 miles which the "Devastation" would run, that this has nothing to do with the formula which has been described. The supposition is that a ton of coals would carry her on an average a certain number of miles. The assumption made is simply that and nothing more. With regard to the "stability" and "cement" question, I might avoid it at this late hour of the evening, and pass on to something else, but I may just say that the loss of the "Captain" caused very great attention to be paid to the "curve of stability." We never had given much attention to it before, and it is that which has mainly led to the introduction of "cement ballast" into ships which were not originally intended to have it. But I have this to say with regard to those ships, that while you could have got the stability by breadth of beam

instead of by putting ballast in, there would have been a disadvantage in doing so. The disadvantage is, that as the ship lightens, you lose stability very rapidly if you get stability by breadth of beam, but if you have got it by putting in ballast you do not. A ship will bear being lightened very much better if she has ballast in her than if she has simply got breadth of beam. With regard to these coast defence ships, I call you sailors to witness whether if these models ("Glatton" and "Cyclops") had been put before you three years ago, you would not have said "that's "the very kind of ship we ought to be building," I say we naval architects did but follow, and that you have driven us. With regard to the compound engines, they are being introduced very largely, in fact generally, into the Navy as they ought to be. I am sure Sir George Sartorius will be pleased to know that while there have been no rams proper described to-night, all the armoured vessels have been provided with that powerful instrument.

The CHAIRMAN: I have now only to perform the last part of my duty, which is to thank Mr. Barnaby in your name for the very able paper he has read to us this evening. It is a great satisfaction to all connected with the Institution to find a man in his official position coming here and candidly telling us his story. He has brought before us a vast amount of information which, when printed in our Journal, will form a very compendious and instructive history of what has taken place during the last ten years with regard to the building of our vessels of war. This information we naval officers find a difficulty in getting, and having it presented to us by Mr. Barnaby in this compact form, should make us doubly grateful to him for having brought it before us this evening.

LECTURE.

Friday, February 2nd, 1872.

GENERAL SIR EDWARD SABINE, K.C.B., R.A., late President of the Royal Society, in the Chair.

ON THE PRESENT STATE OF OUR KNOWLEDGE RESPECTING THE MAGNETISM OF IRON SHIPS, AND THE TREATMENT OF THEIR COMPASSES.

By Staff-Captain FREDERICK J. O. EVANS, R.N., F.R.S., Hydrographic Department of the Admiralty.

TWENTY years have nearly elapsed since an ardent investigator in magnetic science—the late Dr. Scoresby—delivered a lecture in this theatre particularly addressed to the naval profession, and which I had the privilege to hear. In that lecture he expounded certain principles relative to the development of magnetism of a high degree of force, in ships built of iron, during their process of construction;—the special individuality of the distribution of this acquired magnetism depending essentially on the position of the ship's keel and head while building; and also on the subsequent changes which he considered this magnetism must undergo under conditions of mechanical violence or the straining at sea of the ship. Many of his propositions were illustrated by experiments of a simple kind, which, notwithstanding their simplicity, left a lively impression on his audience.

Dr. Scoresby was no alarmist;—but the views he entertained of the instability of an iron ship's magnetism, as affecting her security in navigation, and the danger attending the use of permanent magnets to correct the consequent errors of the mariner's compass; combined with his well-known character as a skilful and bold seaman in youth, philosopher and divine in mature age; influenced the seamen of the period and created much distrust in their minds as to the soundness of certain methods of correction adopted (the result, it may be observed, of a thoroughly scientific investigation), and the consequent security of the ship.

Had Dr. Scoresby been spared to the present time, we may be as-

sured that he would have been gratified in a double sense at the progress of our knowledge of his cherished branch of science; in the first place, because those principles he had so sagaciously elucidated on theoretical considerations from experiments on a very small scale, were confirmed by modern observations embracing ships of a size undreamt of by him, culminating in the "Great Eastern," and armour-clad warships of nearly 7,000 tons. In the second place, he would have been gratified that those principles which he had set forth as to the insecurity attached to the navigation of the iron ship—based chiefly on the reports and opinions of others—were not justified except when the teaching of science had been neglected or evaded.

From official connection with the Admiralty Compass Department, and association with other workers in the field of magnetism, I have been for many years naturally deeply interested in that science in so far as it relates to navigation; a branch of science that I may here observe, affords a wide field for research, and which is by no means exhausted; though much, very much, has been done. It has in consequence fallen to my lot on two previous occasions, namely, in 1859 and 1865, at the invitation of the Council of this Institution, to read papers to the Members on the same subject that formed the life-long study of Dr. Scoresby. The invitation of the Council to address you is again extended to me; my endeavours, therefore, will be to place before you in the short time at my disposal, those leading facts and principles bearing on the magnetic features of iron ships, and the treatment of their compasses, which mark the progress of our knowledge from the days of Scoresby, as also the general conditions of the question at the present time.

I will first, however, give a concise review of the subjects touched on in the papers of 1859 and 1865, as my desire is to avoid, as far as possible, a repetition of what has already been before you, and to be found in the Journals of the Institution.

The Paper of 1859, gave a slight historical sketch of what had been observed in relation to the deviation of the compass on board ship by the old navigators, and of the several methods proposed for the correction of those errors. The experiments and investigations of the Astronomer Royal in 1838-9 on iron vessels, in the then early days of iron shipbuilding, were touched on, as well as the treatment of a ship's deviation table, by Archibald Smith—a name now well known in connection with magnetical science—for finding the five co-efficients A, B, C, D, E, which represent the resolved values of the magnetic disturbance at the particular compass; together with the results of this method of investigation when applied to certain wood and iron-built ships of that period. The magnetical investigations of Dr. Scoresby, and the labours of the Liverpool Compass Committee at that time actively engaged, were further noticed.

The paper of 1865 treated in much detail the magnetism of iron and ironclad ships of war, for in the interval from 1859 great advances had been made, both in the theory and practice incidental to this branch of

the navigator's art. The necessity had, as it were, been forced by the unlooked-for introduction of armour plating, gun turrets, shot-proof transverse bulkheads, and such like masses of iron in ships of war, together with the general employment of iron for decks, beams, and other internal fittings of the ordinary ship; and thus the approximate mathematical formulæ in use in 1859, and which sufficed for the moderate compass deviations of the early iron ships, ceased to be applicable.

The necessary extension of the mathematical theory was undertaken by Archibald Smith, and this revision, together with that of the practical methods for ascertaining and applying the deviation, were given in the Admiralty Compass Manual which then (1865) had reached a second edition, and, at the present time (1872), a third.

This manual is in its several parts concisely described in the paper of 1865, together with the practical adaptations of its more important formulæ; and the numerical values of the several parts into which the errors of the compass are divided in their mathematical treatment, whether with the ship upright or heeling, are given for those of the armour-plated ships of war which had been built, equipped, and undergone sea service in the interval from 1859.

The principal conclusions then drawn from the application of observation and theory to the magnetic phenomena in iron ships followed, with general remarks on magnet correction and other details incidental to the subject.

The paper appropriately closed with the substance of a *vivâ voce* explanation by Archibald Smith, on what, before the later investigations referred to in the paper, were the most obscure of the varied magnetic phenomena observed in an iron ship; namely, that part of the deviation which arises from the transient magnetism induced in the soft iron of the ship by the earth's magnetic force, and which is independent of the position occupied by the ship in building.

This *résumé* of an obscure question, illustrated as it is by the action of "three soft iron rods," and which alone appears in this form in the Journal of this Institution, has always appeared to me a model for clearness, accuracy, and conciseness of what, to most minds, would be conflicting and complicated. I regret that on the present occasion my esteemed friend and fellow-labourer cannot be present from the state of his health.

To resume the subject of the present state of our knowledge of the magnetism of iron ships, and its collateral branch, the treatment of an iron ship's compasses.

The most important feature of the first part of my subject as being the foundation of our knowledge, is its mathematical treatment; this must be understood to include the algebraical formulæ together with their arithmetical processes and the several geometrical or graphic constructions so useful to the navigator as well as to the analyst. Time will not permit me to touch on these details; there is, however, little necessity, as the Admiralty Compass Manual will be found a complete storehouse. I propose instead to confine myself mainly to a sketch of

the leading practical deductions drawn from the discussion of those observations in iron ships, which have been reduced to their several numerical values by the mathematical appliances referred to.

You will see that I am justified in this procedure by the views taken by the President and Council of the Royal Society so far back as the year 1865, as expressed in the following extract from a communication of that body to the Board of Trade on the expediency of a systematic supervision over the adjustment of the compasses of ships of the mercantile marine:—

They say "The theory of the deviation, its causes and its laws, is now "thoroughly understood and reduced to simple formulæ, leaving the "numerical magnitude of a certain small number of quantities to be "determined by observation for each ship separately; and further by "recording, reducing, and discussing the deviations which have been "observed in the ships of the Royal Navy of different classes; nume-"rical results as to the values of these quantities of ships in each "class have been obtained which promise to be of the greatest use in "facilitating the complete determination of the deviation and its cor-"rection . . . .

"The science of magnetism in relation to navigation is in fact in a "position in some degree analogous to that in which the science of "astronomy at one time was. The principles of the science have been "established, the formulæ have been obtained, but numerical values "are wanted, which can only be derived from a large number of ob-"servations systematically made and discussed."

Although, as will be seen by the extracts just read, no doubts exist in the minds of those who have patiently investigated and applied the apparently slow enunciations of science in reference to the mathematical treatment of the iron ships' magnetism; still to a comparatively recent date, it had scarcely commanded the confidence of the naval profession. Seamen appeared either to fail in appreciating the true value of a scientific mode of treatment, or perhaps hoped that some short road might be discovered involving no labour or thought to follow out, and, of course, no science to evoke, and thus at once settle the question of the practical and perfect working of the mariners' compass.

I should be wanting in allegiance to scientific truth as opposed to such popular fallacies, were I not here to state my conviction that the general formulæ elaborated by the mathematician to give the navigator security and confidence in his compass, do satisfactorily represent the observed phenomena productive of error, in every class of ship yet come under investigation; and I would further add, that I cannot conceive how the complicated details of an iron ship's magnetic features can be understood, and the numerous sources of error affecting the compass recorded, and, as far as possible, eliminated, without such mode of treatment.

Before passing from these considerations of the theory, permit me to read to you an extract from an article in the *Quarterly Review* for October, 1865, on the Mariners' Compass, written by a distinguished

mathematician, who in the interests of literature had mastered the subject. In a few brief sentences you will be told to whom homage is due:—

The writer says: "It would be out of place in these pages (even if "our space allowed it) to enter into any detailed examination of the "extremely elegant mathematical investigation first published by "Mr. Archibald Smith in the "Philosophical Transactions" of 1847, "and to be found in a more mature shape in the last edition of the "Admiralty Manual on Compass Deviation. The briefest possible "account of the general character and broad results of the work and "its relation to earlier investigations, is all that is practicable here. "The first mathematician who attacked the problem of the disturbance "of the compass by external attraction, was the eminent French philo- "sopher, Poisson. After the manner of his country, Poisson treated "the question in its greatest generality, and obtained formulæ giving "the deviation of a needle under the combined influence of any ar- "rangement of magnetized and unmagnetized iron. Beyond this point "the labours of Poisson were of little practical service, and it remained "for others to give a real significance to the arbitrary constants of "his formulæ, by tracing their connection with the actual construction "of a ship, and reducing them to a form which would admit of a direct "application of the theory to practice.

"To the Astronomer Royal belongs the credit of having first dealt "with the investigation of this practical problem, in the year 1839, in "connection with his experiments on the 'Rainbow' and 'Iron- "sides;' and for a time his papers, printed in the 'Philosophical "Transactions' for 1839, contained the only available theory on the "subject. Although it has since been found necessary to build up the "formulæ for practical use upon a more rigidly accurate basis, it is "impossible to over-estimate the importance of Mr. Airy's first conquest "in what was then an obscure and almost untried field of science. "The novelty of Mr. Archibald Smith's treatment of the subject at a "later epoch, consisted simply in discarding all arbitrary assumptions "whatever, and dealing with the actual problem on the footing of "Poisson's equations, which by a series of elegant transformations he "reduced to forms admitting of immediate practical use, and bearing "their own physical interpretation on their face. Certain happy geo- "metrical constructions, by which the theory is made available for the "seamen without the necessity of referring to the mathematical "formulæ, are not the least valuable and original portions of the "investigations."

In my paper of 1865, you will find noticed the magnetical features of six of our earliest armour-clad war ships, with the numerical values of their co-efficients. Between the year 1865 and the present time, our armour-clad ships have been greatly increased, and several novel types of war-vessels introduced.

Five troop-ships of large dimensions have been added to the ordinary class of iron ships, together with three large cruizers sheathed with wood, and several small iron unarmoured gunboats.

A distinct class of vessel has also come into prominence in the same period; eighteen cruizers of about 450 tons each, constructed on what may be termed a complete "composite system" of wood and iron; and nearly thirty more of much larger tonnage, some reaching 1,500 tons, on a partly "composite" system. The vessels on the complete composite system have their ribs, beams, stringers, and upright supports constructed of iron, and conform in magnetic character in a very marked degree, to the iron built ship; in the partly composite vessels the iron ribs are wanting, and their magnetic character is less distinctly marked.

The custom of the Admiralty Compass Department is to allow no vessel of any of the classes to which I have referred, to proceed in the first instance to sea without their complete magnetic history being known; this includes not only the forming tables of deviations for their several compasses, but also the values of the horizontal and vertical magnetic forces of the ship at the compass stations as compared with the earth's magnetic force. The observations for this history are not unfrequently commenced when the ship is on the stocks.

These observations, together with such as may be subsequently made in the course of the ship's service, are reduced by the appropriate formulæ and the several resulting co-efficients and their constituent parts recorded for future reference.

Appended is a Table containing the magnetic elements of a few ships of various types. It is introduced as illustrative of the method of recording the several co-efficients and their constituent parts;—as also showing the increasing amount of error, especially that arising from the induced forces, the consequence of the increased amount of iron employed in the construction of the modern vessel.

The steam-ship "Rainbow" (in the first column) is the first ship experimented on (1838) to determine the nature of the magnetism of iron vessels and the co-efficients are those resulting from the Astronomer Royal's observations. The merchant ship "Clyde," in the second column, is a fair type of the modern iron ship, and is introduced to compare with the "Rainbow." The remaining examples are types of modern ships of the Royal Navy. In the last column are the co-efficients at a compass near the steering wheel between decks, on the starboard side, in the "Cyclops" turret ship: the co-efficients A and E in their large values are confirmatory of the theoretical principles established for compasses that are placed out of the midship line of the vessel—these co-efficients at compasses in the midship line are usually zero.

Table of Magnetic Elements of various Ships,

		Merchant Ships.	
		Steam-ship. 500 tons.	*Sailing ship. 1,100 tons.*
Ship's name		"Rainbow."	"Clyde."
Head built		*to N.N.W.*	*to N.E.*
Observed	Place	Deptford.	Greenhithe.
	Date	1838.	1863.
		° ′	° ′
Approximate Co-efficients of Deviation.	Constant ... A ..	+ 0 35	+ 0 41
	Semicircular ... B ..	−18 45	− 7 56
	Semicircular ... C ..	−12 57	+ 7 25
	Quadrantal ... D ..	+ 2 30	+ 4 43
	Quadrantal ... E ..	+ 0 02	+ 0 08
Exact Co-efficients of Deviation.	Constant ... $\mathfrak{A}$ ..	+ ·010	+ ·012
	Ship's force to head ... $\mathfrak{B}$ ..	− ·327	− ·143
	Ship's force to starboard .. $\mathfrak{C}$ ..	− ·217	+ ·124
	Induced forces ... $\mathfrak{D}$ ..	+ ·044	+ ·082
	Induced forces ... $\mathfrak{E}$ ..	+ ·001	+ ·002
Maximum semicircular deviation or $\sqrt{B^2 + C^2}$ ..		$22\frac{3}{4}$°	11°
Mean Horizontal force of ship. (*Mean force to north* (λH) *being unit.*)	Amount ... $\sqrt{\mathfrak{B}^2 + \mathfrak{C}^2}$ ..	·392	·189
	Direction, or "starboard angle" $\tan^{-1}\frac{-\mathfrak{C}}{\mathfrak{B}}$ ..	213°	139°
Mean Horizontal force on board to north, or λ .. (*Earth's horizontal force* = 1·0.)		·972	·870
Fore and aft horizontal induction, or ... a ..		+ ·015	− ·059
Transverse ditto or ... e ..		− ·071	− ·201
Parts of D	from fore and aft induction ...	+ 0° 24′	− 1° 57′
	„ transverse „ ...	+ 2 07	+ 6 39
Mean vertical force on board, or ... μ.. (*Earth's vertical force* = 1·0.)		—	1·275
Heeling error for 1° of heel of ship. ... (+ *to windward* − *to leeward.*)		—	+ 1° 22′
Heeling Co-efficient	from vertical induction in transverse iron ...	—	+ 0 35
	from vertical force and induction in vertical iron ...	—	+ 0 47
Variable part of vertical force, or $\frac{g}{\tan \text{dip}}$ ...		—	—

at selected position of Standard Compass.

Indian Transport.	Modern war ships.			
4,173 tons. *700 h.-p.*	*Composite build.* *4 guns.* *467 tons.*	*Iron gunboat.* *245 tons.*	*3,893 tons.* *14 guns.* *800 h.-p.*	*2,107 tons.* *Turret ship.*
"Serapis."	"Avon."	"Kite."	"Swiftsure."	"Cyclops."
Built North, fitted S.S.W.	*S. 57° E.*	*S. 34° W.*	*Built S.56°W. fitted N.N.E.*	*Lower deck compass.*
Greenhithe.	Portsmouth.	Greenock.	R. Tyne.	Sheerness.
1867.	1868.	1871.	1871.	1871.
° ′	° ′	° ′	° ′	° ′
− 0 56	+ 0 33	+ 1 55	+ 0 38	− *5 0*
−18 56	+17 04	+33 16	+20 15	−36 09
− 5 24	+20 20	−18 20	− 9 43	+16 04
+ 4 51	+ 4 01	+ 8 35	+ 7 18	+13 45
− 0 18	+ 0 10	+ 0 05	+ 0 10	− *6 43*
− ·016	+ ·009	+ ·033	− ·011	− ·087
− ·339	+ ·300	+ ·588	+ ·368	− ·679
− ·089	+ ·333	− ·138	− ·156	+ ·266
+ ·085	+ ·070	+ ·149	+ ·127	+ ·240
− ·005	+ ·003	+ ·001	+ ·003	− ·117
19¾°	26½°	38°	22½°	40°
·351	·449	·604	·490	·729
19½°	48°	347°	337°	159°
·905	·920	·822	·790	·486
− ·017	− ·016	− ·079	− ·110	− ·398
− ·173	− ·144	− ·277	− ·310	− ·630
− 0° 32′	− 0° 28′	− 2° 46′	− 3° 56′	−24° 05′
+ 5 27	+ 4 29	+ 9 44	+11 14	+40 24
1·170	·819	·705	1·118	*strong upward force.*
+ 0° 57′	− 0° 06′	− 0° 04′	+ 1° 29′	—
+ 0 29	+ 0 23	+ 1 0	+ 1 05	—
+ 0 28	− 0 29	− 1 04	+ 0 24	—
+ ·024	+ ·049	+ ·039	+ ·076	—

On examining these general records to the end of 1871, I find that, excluding our wood-built fleet, we have more or less complete the magnetic history of—

25 Iron armour-clad ships,
14 Wood armour-clad ships,
9 Iron armour-clad turret ships,
3 Unarmoured iron cruizers sheathed with wood,
12 Iron gunboats of small dimensions,
50 Iron ships of ordinary construction, varying in size from "Great Eastern" to vessels of 300 tons,
18 Composite build (complete) cruizers,
28 Composite build (incomplete) cruizers.

For these 159 vessels 1,250 deviation tables have been resolved into their several co-efficients, A, B, C, D, E. 400 of these tables have been accompanied by force observations for the determination of the co-efficient λ *(lambda)*, or the mean horizontal magnetic force of the ship to the north as compared with the earth's horizontal magnetic force, and about 300 determinations of the ship's vertical magnetic force as compared with the earth's vertical force: the latter made in order to obtain the amount of deviation due to those forces, which, when the ship was upright, acted vertically and did not disturb the horizontal compass-needle, but when the ship heels over produce a sensible error, technically known as the "heeling error."*

For some of the armour-clad ships we have 30, 40, 45, and in one ship 53 deviation tables, divided between the standard compass, the steering, and other compasses, including those below decks.

The several discussions of these extended observations, combined with those made in former years by the Liverpool Compass Committee, as resulting from the varied experimental investigations made by Messrs. Towson and Rundell (see the three Reports, 1857—61) lead to certain definite conclusions, the chief of which may be thus summarized as general principles.

1. The magnetism of iron ships is distributed according to precise and well determined laws.

2. That a definite magnetic character is impressed on every iron ship while on the building-slip, which is never afterwards entirely lost.†

3. That in an iron-built ship, and in that part of her within which the navigating or standard compass is generally placed, the polar force is that from the magnetism of the whole body of the ship, and is nearly uniform; and that we cannot escape from the action of that force by any care in the selection of a place for the compass.

* The observations and reductions in late years have been made by Staff Commander William Mayes, Superintendent of Compasses, and an assistant officer, Navigating Lieutenant Ettrick W. Creak, R.N. Navigating Officers of the Fleet have also contributed observations from abroad.

† See Fig. 1. These theoretical deductions of Scoresby are amply confirmed by experiments made in iron ships of all sizes, built on various azimuths.

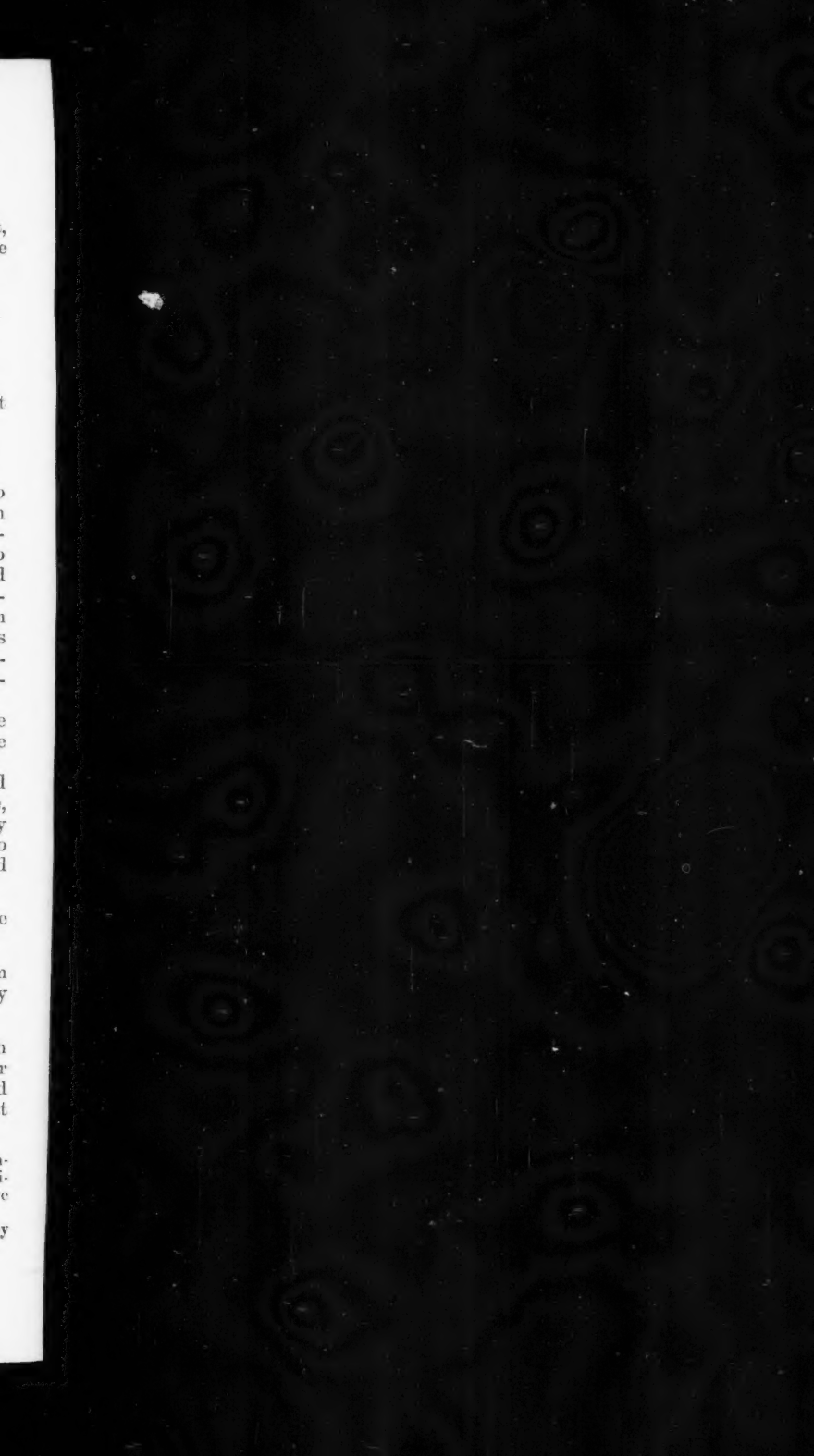
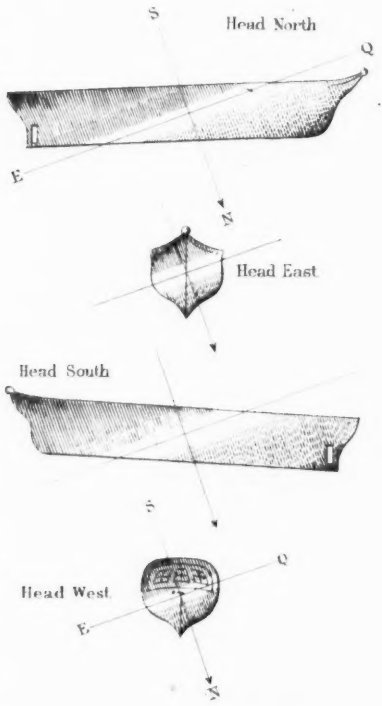


Fig 1

Magnetic Polarity of Iron Ships built in Great Britain_Dip 68° to 70° N

(From theoretical deductions by the late D^r Scoresby)



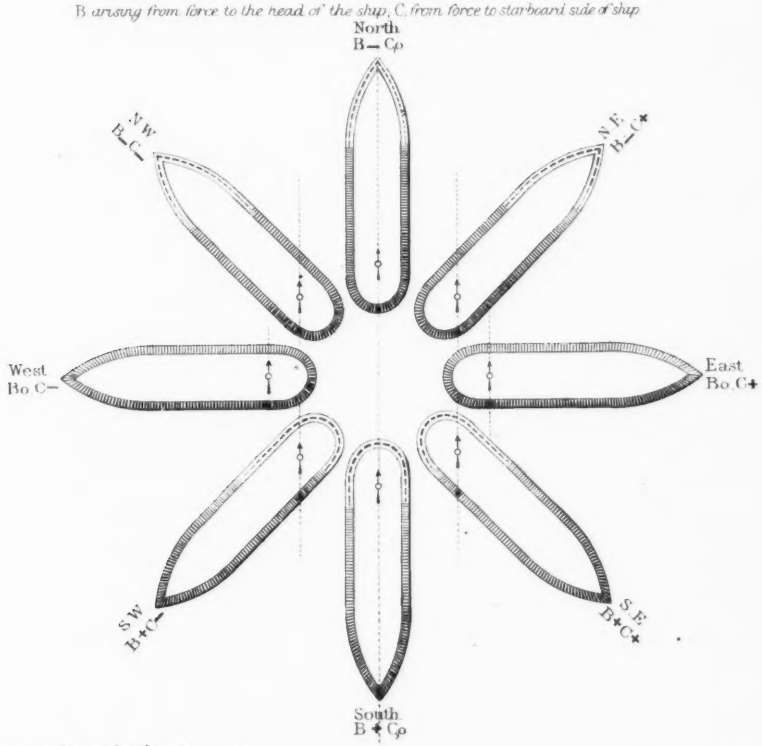
The axial Line SN represents the direction of the dip or line of magnetic force, passing through the general centre of gravity of the material of the ship, the parts of the ship below the Equatorial line E Q shaded with broken lines, have North polarity, (or repel the north end of the compass needle); the parts above shaded with firm lines, have South polarity (or attract the north end of the compass needle.)

Fig 2

Diagrams showing Polarity of the topsides of an Iron Vessel, according to the direction in which her Head may be built with reference to the Magnetic Meridian

(Appended are the signs of the co-efficients of Semicircular deviations)

B arising from force to the head of the ship, C from force to starboard side of ship



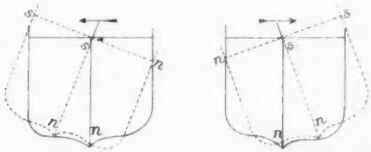
indicates South polarity (attracting north end of needle)

North polarity (repelling north end of needle)

The intensity of the shading a corresponding intensity of Magnetism

dotted lines through compass needles, line of Earth's force to north

Fig 3 *To illustrate Heeling error*



The letters n, s, indicate the polarity of the vertical soft iron, as obtained by induction from the Earth's vertical magnetic force, when the ship heels to starboard or to port.

4. That the definite magnetic character of an iron ship, so far as relates to the polar forces developed in her during construction, is shown by the connection which exists between the direction of the ship's original magnetism and the direction of her head when on the building-slip; for the original semi-circular deviation consists principally in an attraction of the north point of the compass-needle to the part of the ship that was south (or nearly so) in building.*

5. That a great reduction takes place in the magnetism of an iron ship on first changing her position after launching, and that her magnetic state is then unstable for a short period. Then, after a few months' service, perhaps within a year for the average of ships, the time probably depending on the nature of the iron employed in the construction, the magnetism of the ship acquires a very stable character.

6. That in iron-built ships, as at present constructed, the ship's polar force is generally so great as to make it necessary to employ magnets to equalize the directive force on different azimuths of the ship's head, even at the most carefully selected position.

The investigation of the numerical values in more extended detail lead to inferences which I will now place before you.

Respecting the Semi-circular Deviation.

Though on general theoretical considerations of the distribution of magnetism in the iron ship's hull, a position for the compass could be selected where large errors might be avoided, still the practical requirements of the seaman and the architect frequently interpose to prevent choice of site; the magnetic action of the diverse interior fittings and equipment of the modern iron steam-ship are also not unfrequently of an amount sufficient sensibly to affect the resultant error as due alone to the hull, although the latter, it must be observed, will always be found to dominate. We find from these considerations that the amount of semi-circular deviation in ships of similar classes at compasses similarly placed are not comparable; in fact, we must consider each ship to have its own polar-magnetic constitution. This dissimilarity of constitution does not exist when we examine into the values of their induced forces.

The following table, for example, exhibits the values of the *maximum* semi-circular deviation in several classes of vessels at the standard compass in selected positions:—

In six iron gunboats, of 245 tons each, from ..	19° to 44°
In fifteen composite gunboats, of 465 tons each, from	15° to 25°
In five Indian transports, of 4,200 tons each, from	17° to 29°
In three iron cruizers, wood-sheathed, 2,300 to 4,000 tons each, from	32° to 43°†

* See Fig. 2.

† I am disposed to consider that the high values found in these three ships, "Inconstant," "Volage," "Active," arise from the extra hammering involved in sheathing their bottoms with wood preparatory to coppering.

In six armour-plated ships with central batteries, of 3,800 tons each, from.. .. .. .. 20° to 48°

The general proposition that a great reduction takes place in the magnetism of a ship on first changing her position after launching, but that after a few months' service the magnetism acquires a comparatively stable character, is sustained by evidence extending over many years. It is difficult to assign numerical values to these changes where so much diversity of character exists in the several types and constitutions of ships; but we may assume that in the first month or two after launching, and if in the course of equipment her head has been on different azimuths, about one-fifth of the semi-circular deviation that existed when on the stocks, would be dissipated. This is in accordance with a few cases actually observed. From this time until the period of stability is attained, the residual semi-circular deviation further decreases by about another one-fifth.

In reviewing these changes and those that subsequently arise from the changes of geographic position, we must consider that although the principal part of the semi-circular deviation is caused by permanent, or as we may more properly call it, sub-permanent magnetism: a residual part is independent of the ship's position in building, being the effect of *transient* magnetism induced in the ship by the earth's vertical force. It is the first and largest of these parts that diminishes so much in the early history of the ship, and which subsequently attains its fixed and permanent character, while the smaller residual part probably changes little, if at all, so long as the ship remains in the same magnetic latitude. On change, however, of magnetic latitude, this residual part rapidly changes, and its effect on the north end of the needle is reversed on the ship attaining the southern magnetic hemisphere.

Now if a compass is properly placed with reference to vertical iron by there being a fair distribution of the latter on either side, before or abaft the compass, the changes arising from the sub-permanent and transient magnetism induced by the earth's vertical force would be very small; while if unfavourably placed, such as being near the rudder-head and sternpost, there would assuredly be very large changes on change of magnetic latitude.*

At the standard-compass of many of the ordinary built iron ships in the Royal Navy, it is found that not only is the semi-circular deviation very constant in amount,—showing the stability of the magnetism,—but that on great changes of geographic position it is found

* There is an existing but fallacious belief that in every iron ship a place can be found where all the "magnetic influences balance," or a *neutral point* where a compass can be placed free from errors of any magnitude. At a recent discussion in the Institution of Naval Architects, this belief was put strongly forward, and it was further stated that such a neutral point existed in H.M. Ships (p. 245 of "Transactions" for 1871). The statement is erroneous, and the belief is only true thus far, that in some few ships a position may be found where, from the magnetism of a particular mass of iron—such as the rudder-head—counteracting that of the ship, the semicircular deviation will be small; yet such positions are in general to be avoided, as the change of magnetic force there will probably be larger and less regular than when the compass is only acted on by the general magnetism of the whole ship. Such positions of insecurity are certainly avoided in H.M. Ships.

to arise from permanent magnetism; a fact rendered obvious from the semi-circular deviation varying at a rate inversely proportional to the value of the earth's horizontal force, and not directly proportional to the value of the tangent of the magnetic dip. In these ships the changes of deviation ensuing on any part of their voyage can be confidently predicted.

As an approximate rule, in the ordinary iron-ship built in England at a well-placed compass, from one-fourth to one-eighth may be taken for the induced part or that affected by changes in the dip, and from three-fourths to seven-eighths of the whole magnetism for the permanent part. The changes of deviation on change of geographic position can thus be approximately predicted.

In the armour-plated ships the amounts of the induced and permanent magnetism appear to be nearly equal, although it is worthy of observation that the changes of semi-circular deviation in their early history are less marked than in the ordinary type of iron-ship, and that its settled value is sooner established; conditions probably arising from the increased amount of hammering in the progress of their construction.

On the Loss of Directive Force in the Compass-needle and the Quadrantal Deviation.

One of the most remarkable features in the iron-ship's magnetism, as arising from the increased use of iron in their structure, is the increasing prejudicial effect on the action of the compass by the mean directive force of the needle being in consequence diminished; by this diminution of force, the effects of all the disturbing forces on board, especially those which may arise from the friction on the needle, due to imperfect workmanship or wear, are increased.

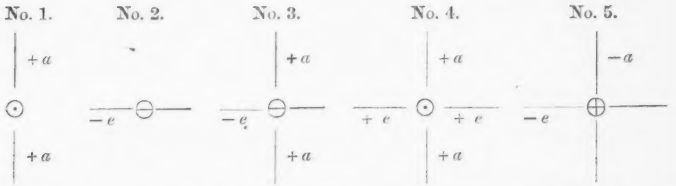
It will be seen by the tabulated coefficients of the several vessels that are appended, that while in the early constructed iron-ship experimented on by Mr. Airy, the mean directive force to the north acting on the needle, or (λ), is ·970, or a loss of only ·030, as compared with the earth's horizontal force considered unity; in a similarly placed compass on board the modern iron merchant-vessel "Clyde," it is ·870, a loss of ·130, or about one-eighth. At the standard-compass of our armour-plated ships, λ is generally not more than four-fifths, and at their main deck compass three-fourths of the earth's force, while within the breast-work of the "Cyclops" class it is reduced to nearly one-half.

As these striking facts do not appear to have been recognised by those projectors who aim at demagnetizing the iron ship, it is desirable, perhaps, here to state that it admits of experimental proof, that this diminution of force is not the effect of permanent magnetism, but alone arises from induction in the "soft" iron of the ships by the earth's horizontal force, and that were it possible to demagnetize or depolarize the ship, this diminution, or the quadrantal deviation which arises from the same cause, would not be affected.*

* If we place a compass over a circular plate of purely soft iron, no deviation will be

Now the quadrantal deviation (D), which assumes a large value in our modern ships, especially when armour-plated, admits of the same experimental proof that it can alone be caused by *horizontal* induction in *soft* iron, and thus its connection with λ.

Conceive, for example, the following arrangements of soft iron in which the ship's head is supposed to be directed towards the top or bottom of the page.



We may consider + a to represent masses of soft iron entirely before or abaft the compass, as engines, boilers, funnels, iron masts, &c.

" − a " soft iron extending through the position of the compass, as the keel and hull of the ship, screw shaft, armour plating, &c.

" − e " the effect of all the transverse soft iron, as the bottom of the ship, iron decks, iron beams, &c.

" + e " masses of soft iron which lie to one side of the compass, as guns, davits, or when the compass is in or over a hatchway.

Between these various arrangements there is this important difference, that in Nos. 1 and 4 the directive force of the needle would be increased, while in Nos. 2 and 5 it would be diminished; in No. 3 it might be either increased or diminished, or left unaltered, as the effect of the longitudinal and transverse iron preponderated.

For the deviation, as the ship swings round—

+ a will give a *positive* quadrantal deviation.*
− a " *negative* "
− e " *positive* "
+ e " *negative* "

próduced, but the directive force of the needle (as shown by the slowness of its vibrations, when compared with those made in a place free from disturbing causes) will be diminished, arising from the magnetism induced in the circular plate by the earth's magnetism, acting in a direction antagonistic to that of the earth's force. A similar effect is produced when the compass is enclosed in an iron vessel or a hollow shell; hence we see how a compass placed above an iron deck, and still more between iron decks, loses a great part of its directive force.

* *i.e.*, a deviation of the needle to the east in the 1st and 3rd quadrants, to the west in the 2nd and 4th quadrants. A *negative* quadrantal deviation is the reverse of the foregoing, *i.e.*, west deviation must be substituted for east, and east deviation for west; in both cases + sign representing east deviation, − sign, west deviation.

To illustrate parts of Coefficient D, (or the quadrantal deviation

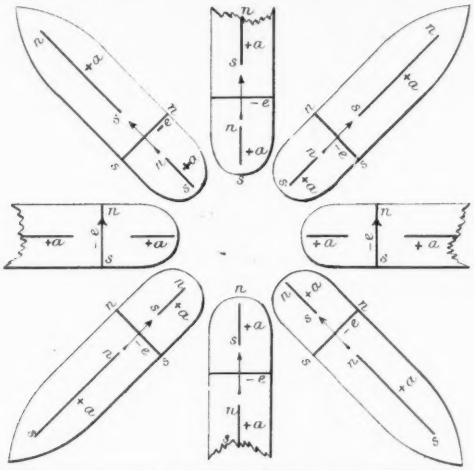


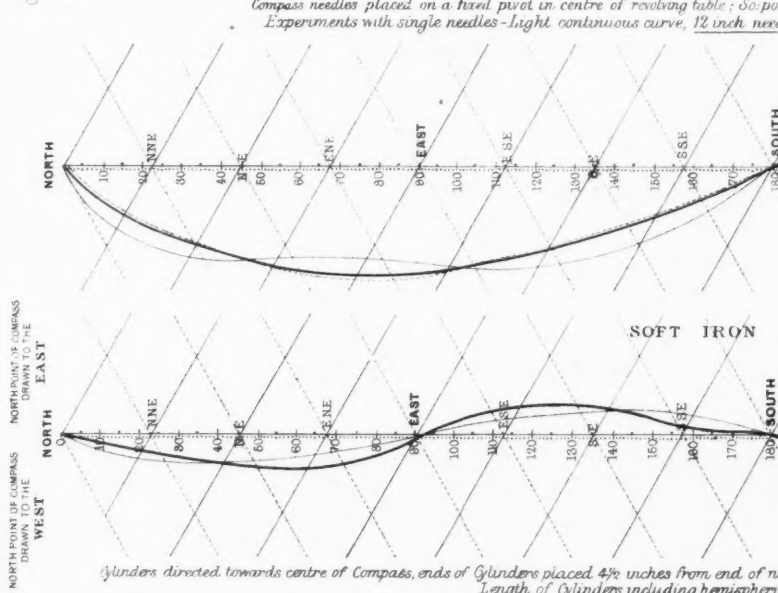
Fig. 4.

Note. The letters
polarity of the hor
as obtained by ind
Earth's horizontal
in the successive a
ship's head.

Fig. 6.

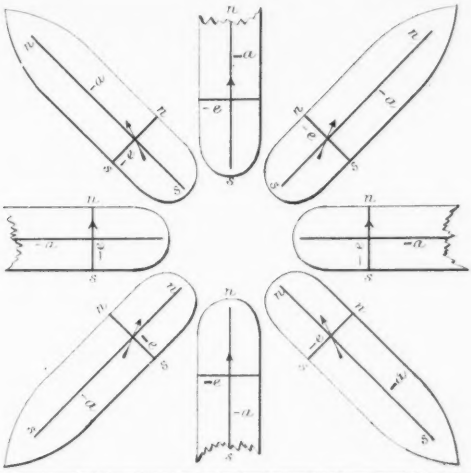
MAGNET E

Compass needles placed on a fixed pivot in centre of revolving table; So po
Experiments with single needles - Light continuous curve, 12 inch nee



Cylinders directed towards centre of Compass, ends of Cylinders placed 4½ inches from end of n
Length of Cylinders including hemispher
Light curve. Compound Needles, Admiralty Standard Compass

-deviation.) arising from fore and aft and transverse Induction in soft iron of Ship

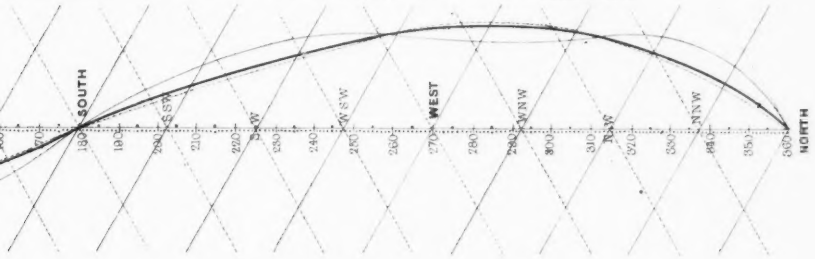


The letters n s indicate the ity of the horizontal soft iron ined by induction from the horizontal magnetic force successive azimuths of the ead.

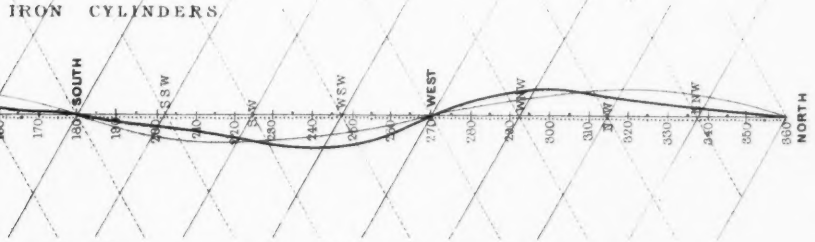
Fig. 5.

NET ENDWAYS

table ; So. pole of 12 inch bar magnet 19·25 inches from the pivot, 2·75 inches below its level. 12 inch needle ; Black continuous curve 6 inch needle ; Light dotted curve 3 inch needle



IRON CYLINDERS.



m end of needles, or in same position as adopted for correcting the Quadrantal deviation of an Iron Ship
hemispherical ends 12 inches, diameter 3 Inches.
rd. Compass card 7.6 inches - Black Curve, Single Bar Needle, 7.5 inches long

J. Dobbins

Applying these principles to the observed facts, it is found, without exception in every iron ship, at the ordinary place of the compass, that the quadrantal deviation is *positive*, or follows the sign + − + − in the successive quadrants NE., SE., SW., NW., from whence we may infer that it is caused by the co-existence of the arrangements of masses of soft iron represented by + *a* and − *e*, as shown in Fig. 4, or the excess of − *e* over − *a*, as shown in Fig. 5.

The investigations of the observed values of D and λ give this result, that the positive value of D arises from the transverse iron continued from side to side, such as beams, decks, bulkheads, and the ship's bottom, producing a large − *e*, and overcoming the force of the fore and aft iron, or *a*; the latter is sometimes, but rarely +, but more generally −, and when − always less than *e* (see tabulated co-efficients); and hence that it is caused by the excess of the thrust on the north end of the compass needle from the north *side* of the ship, over the thrust from the north *end* of the ship.

In this explanation of the causes of the quadrantal deviation, I have somewhat gone over the same ground as in my paper of 1865, but the facts given in that paper on the subject appear by more recent proposals and writings in reference to the magnetism of iron ships, to be entirely overlooked; a serious omission, which I now endeavour to rectify by a reiteration of the principles.

At the standard compass of ordinary iron ships the quadrantal deviation is usually from $4\frac{1}{2}°$ to 5°, in armour-plated iron ships 6° to 7°. On the main deck of the latter class it rises to 8° and 10°, while in the batteries and between decks of the turret ships it reaches the enormous amount of 15° and 20°.

The diminution of the directive force, and the amount of the quadrantal deviation, are nearly the same at the same level in different parts of the ship. They increase in descending from the position of the standard compass to the steering and main deck compasses, particularly in ships having a thick iron deck. The diminution of the directive force, and the quadrantal deviation, both diminish with the lapse of time, there are also grounds for believing that λ is affected by temperature, diminishing by increased temperature, but this consideration does not affect navigation.

Respecting the Heeling Error.

I now arrive at the question of the "heeling error" in iron ships, or that amount of deviation which is superposed on the ordinary deviation of the compass when the ship heels over to port or to starboard from an upright position, and which, for theoretical and practical purposes is in its value indicated for every degree of heel of the ship.

Theoretically considered, the heeling error is a complicated though not an obscure problem; fortunately practically considered, it does not baffle the careful navigator, nor is it without amelioration by partial correction through the aid of magnets, and especially by a proper

position being selected for the compass. In all cases we know that its *maximum* amount occurs when the ship's head is *north or south* by the disturbed compass, and that it vanishes when the ship's head is *east or west* by that compass. So forewarned, the navigator knows when he can ascertain the extreme amount of error from actual observation at sea, and when to use precaution.

The worst possible condition for producing heeling error is when an iron ship is built head north, and the compass placed near the stern,* as that part is strongly magnetised, and all the additional forces developed by the ship's heeling conspire to produce the error. These forces are—

1. Vertical induction in transverse iron, such as the beams, &c.

2. The vertical force from the permanent magnetism of the ship.

3. The vertical induction in all vertical iron situated under the compass, such as the sternpost, stanchions, &c., and each force pulls the north end of the needle downwards and to windward.†

Conversely, the best possible condition for the reduction of the heeling error is in the ship built head south (or from SW. to SE.), when the compass is placed in the after part of the ship; as then force 2, from the reversed polarity of the stern of the ship, operates against forces 1 and 3, and may exceed them in intensity;—if so, a small heeling error to leeward would result. Hence the difference in the heeling errors of individual ships: it is, applying a term I did when speaking of the semicircular deviation, a constitutional error, and one ship affords no guide to another unless all the conditions of build are the same.

The numerical values of the heeling error in the ships of the Royal Navy are about as follows:—At the standard compass of the armour-plated ships, when in England, the worst type does not exceed $1\frac{3}{4}^{\circ}$ for each degree of heel, and it is always to windward; 1° and under would, perhaps, be the average: in all these ships about $\frac{3}{4}^{\circ}$ is found to arise from force 1, or that from vertical induction in transverse iron, the remainder from forces 2 and 3. On the main decks of these ships there is a strong upward force producing a heeling error to leeward.

In ordinary iron ships in England the heeling error from transverse iron averages about $\frac{1}{2}^{\circ}$ to windward, an error it must be remembered which changes with the changes of magnetic dip, and would, therefore, in the southern hemisphere be an error to leeward. The forces 2 and 3 are mixed together in such an uncertain way, depending on the build of the ship and arrangements of iron, that their proportions cannot be estimated.

Fortunately, by a simple class of observations with a dipping needle,

* See paper on the loss of the iron ship "Glenorchy." "Royal Society's Proceedings," 1869.

† See Fig. 3 in illustration, when (1) the weather or upper end of the beams and all transverse iron acquire south polarity (*s*) by induction from the earth (in northern magnetic latitudes); and similarly from induction in vertical iron (3) the south poles are brought nearer the north end of the needle as the ship heels over.

and with the knowledge of the co-efficients D and λ, we can approximate very closely to the error that would be found if the ship were actually heeled, and thus a formidable amount of labour is avoided. The details are fully described in the manuals* on the subject.

When it is considered necessary to correct the heeling error, the practice in the Royal Navy is to employ a magnet a few inches long, which is inserted vertically in the supporting pillar of the standard compass, exactly beneath the centre of the compass needle, a hole being accurately bored for the purpose.

The simple class of observations for finding the heeling error, without heeling the ship; together with those when a horizontal needle is employed to determine the co-efficients B and C, and thus to form a table of deviations, without swinging the ship, are, from my point of view, among the real triumphs in this branch of science. The time and labour that by these means are saved in acquiring a competent knowledge of the ship's magnetic characteristics are important considerations, with the advantages that a secure and desirable position for the compass may be selected while the ship is even on the stocks, and certainly objectionable positions be avoided.

The degree of approximation to correct results in these methods just brought to your notice, depends on the approach to accuracy with which the values of D and λ are assumed, if they are not known. From the numerous records we have now of so many types of ships, it is not difficult to estimate a value for any individual ship, even when new. As a consequence, nearly all the preliminary work of our ships in the Royal Navy is thus effected, nothing is left to chance even when the architect will scarcely give space and place for selection. With the coefficients determined, the correcting magnets are prepared and placed in accordance, and the ship is ready for the thorough "swinging" to form a table of residual errors—errors which are generally small in amount and not embarrassing to the navigator.

It is well to record here that the results obtained by these several methods, approximate closely to those determined by the complete processes of swinging and heeling, and are confidently adopted by the Admiralty Compass Department.

Notes on the Mechanical Correction of Compass Deviation.

After the investigation of the several characteristics of an iron ship's magnetism, the most important consideration is by what means can we correct or reduce the errors so produced on the action of the mariners' compass?

The now universally adopted method of mechanically correcting the deviations of the compass, was proposed by the Astronomer Royal more than 30 years ago, after a series of remarkable experiments and investigations on two of the earliest built iron merchant vessels; and consists, as is well known, in correcting the semicircular deviation produced

* See "Admiralty Compass Manual," 3rd edition, pp. 82—89; and "Elementary Manual," companion to the foregoing, pp. 89—104.

by the ship's polar magnetic force, by the application of permanent magnet-bars; and in correcting the quadrantal deviation arising from the induction in the soft iron of the ship by the earth's horizontal magnetism, by the application of soft iron in masses of diverse shapes.

In past years, as you will have gathered from my opening remarks on the labours of Scoresby, much diversity of opinion prevailed as to the necessity for, and the freedom from danger in the employment of, permanent magnets; the limits of these diverse opinions are now, from circumstances which I will hereafter explain, very much narrowed. Still among, it is to be hoped, a limited few, erroneous opinions exist on this subject, errors too of a nature that can be disproved by simple experiment.*

The general question of the mechanical correction of the deviation of the compass has, on other grounds, materially changed its aspect of late years; the cause arises from the vast increase in the employment of iron in the interior as well as the exterior fabric of the iron ship.

Ships of the mercantile marine, no less than ships-of-war, have been affected by these changes in naval architecture. Before this period of change the deviation of a standard compass, properly placed in an iron ship, seldom exceeded 20° at the maximum, and the directive force which acted on it as the ship was swung, was comprised within two-thirds and four-thirds of the mean force. In the present day it is generally impossible to find a position for this compass at which the deviation and variations of directive force do not greatly exceed these limits. Hence this change in the conditions experienced has produced a corresponding change in the practice of the Royal Navy. Magnet correction is absolutely necessary in nearly every ship-of-war afloat; and broadly I may here state that the results of the system adopted, a system suited to the magnetic knowledge of the day, are satisfactory both as to efficacy and security.

The process recommended by the Astronomer Royal for the mercantile marine and generally adopted, was, as is well known, a tentative one, or an operation simply "to the making the compasses act correctly:" it took no account of the amount or distribution of the magnetic forces at the position of the compass, due to the hull of the ship, or the disturbing action of individual masses of iron masking the magnetic force of the hull of the ship. But a second method was described by Mr. Airy, in his well-known paper on the magnetism of iron-built ships (Phil. Trans. 1839, p. 196), which did require the knowledge of these important details, and it is this method which is generally employed in the Royal Navy. It may be thus explained.

* It has been stated, for example, within the last five years in this theatre, by one naval authority, that the employment of correcting magnets decreases the directive force of the needle, and that "common sense dictated at once the sweeping them away;" by another, that they lessen the tendency of the seaman's "guide, philosopher, and friend" (an euphuism for the compass needle) to point truly. These misconceptions will doubtless pass away with the spread of sound knowledge, for in fact, magnets cannot affect the mean directive force, while soft iron correctors increase it.

The co-efficients B, C, λ being found by observation, or when necessary, B and C being found by observation and λ estimated; we have $\sqrt{B^2+C^2}$ the tangent of the semicircular deviation when the polar force acts to the east or west of the compass, and $\frac{C}{B}$ the tangent of the starboard angle. If we desire to correct the semicircular deviation completely, a magnet of suitable size, adequate power, and proved permanence, is selected. The distance above or below the card at which this magnet, when placed east and west, will produce on shore a deviation of which the tangent is $\lambda \sqrt{B^2 + C^2}$ is ascertained by trial. The magnet is then inserted into the pedestal of the standard compass at the ascertained distance immediately below the centre of the card, and in the direction of the starboard angle, the pole being so placed as to counteract the polar magnetism of the ship. In newly built ships, the polar force, as before mentioned, is generally undergoing a process of gradual diminution, it is therefore generally considered best not to correct entirely the semicircular deviation, but to under correct it.

In general, no attempt is made to correct the quandrantal deviation, that deviation and the residual semicircular deviation being the subject of the tabular correction;—a correction it may be observed now thoroughly grafted in the practice of the Royal Navy, and which practice is certainly productive of security, as its foundation implies that the compass needle must never be considered to point correctly, whatever mechanical correction may be employed.

The question of quadrantal correction by soft iron is a difficult one; it is true that by its neglect a small amount of directive force is lost, and a further small correction of heeling error; the danger, however, that may arise from the large masses of iron necessary for the correction of modern ships taking up polar or permanent magnetism, must be placed as a set off, as also the further consideration that after the correction is effected, all record is lost of the ship's magnetic state.

When the quadrantal deviation is small, as in the ordinary iron ship, it may be, I consider, safely allowed as a residual error; and the omission in practice has this advantage, that it acts as a valuable check on the correctness of the deviation tables constructed by the navigator from the circumstance of the coefficient D remaining constant, or nearly so, under all changes of time and place.

With the large quadrantal deviations at the between-deck compasses of our armour-plated ships, two compasses brought together sufficiently close to produce a *negative* quadrantal deviation equal in amount to the *positive* value of the ship, and then mutually corrected by one system of magnets for semicircular deviation, have proved useful, but the loss of directive power at the place is not remedied. This is a subject now engaging the attention of the Compass Department.

It may be here naturally asked why the practice of compass-correction, which is now considered efficacious and secure, should in the earlier period of the iron ship's history, have been deemed untrustworthy and indeed dangerous? The reply is not difficult; the magnetic

conditions of the few iron ships of the Royal Navy at that period did not as a matter of necessity, require magnet correction—their compass deviations rarely, if ever, exceeded 20°—tabular corrections were readily obtained, and gave ample security. The practice of compass correction was thus confined to the mercantile marine; the process, as recommended by the Astronomer Royal and generally adopted, being purely a tentative one, was easily carried out in practice and involved little or no knowledge of principles: it soon became a branch of ordinary trade business in connection with compass manufacture, and the professional "compass adjuster" has been long established at all our chief mercantile ports.*

Unfortunately, too, the practice of furnishing the seamen with a table of residual errors was not at the same time adopted or its necessity recognized, but on the faith of the professional adjuster, the compass was considered correct.

It was further a prevailing custom at this time in the mercantile marine to use the steering or binnacle compass alone for the navigation of the ship. This compass was usually not more than two feet above the deck beams, and frequently placed in the after part of the vessel near such vertical masses as the stern-post and rudder. Large and irregular deviations were sure to obtain at this position, the large errors requiring to be corrected by large and powerful magnets; the result was that the slightest change in the magnetism of the ship produced a large compass error, and not unfrequently in foreign-going ships proceeding to the southern hemisphere, on reaching the latitude of the Cape of Good Hope, the compass was entirely useless: this arose from the induced magnetism of the rudder and other adjoining masses then acting in unison with those correcting magnets, which originally at the port of departure had been purposely placed to act in direct antagonism.

This indiscriminate use or rather abuse of the method of correction by magnets, was certainly not intended or contemplated by the Astronomer Royal when he freely gave seamen the issue of his valuable labours; but the prejudices arising from the numerous recorded failures, the result of an ignorant application of a sound scientific principle, operated for many years against a proper spirit of enquiry into the causes of failure.

In 1855, however, the Liverpool Compass Committee,† under the auspices of the Board of Trade and with a large number of iron ships of the mercantile marine of that port placed at their disposal, com-

* I am here nearly quoting the words of Mr. Rundell, many years Secretary to the Liverpool Compass Committee, and perhaps the best authority on this point in the country. In a paper read before the Institution of Naval Architects in 1866, "On Compass Equipment in Iron Ships, and Government Supervision," he remarks:—"Experience shows that compass adjusters rarely know more than the mechanical "practice of adjustment, as explained by the Astronomer Royal more than twenty-"six years since—a practice so simple that any person of ordinary ability could, "under good instructions, acquire it in a few hours."

† The formation of this Committee originated from the discussions that took place at the meeting of the British Association for the Advancement of Science, held at Liverpool, in 1854, on a paper by Dr. Scoresby, "On the Loss of the 'Tayleur,' and the Changes in the Compasses in Iron Ships."

menced a vigorous inquiry into the general question of their magnetism, and the correction of their compasses; in their Third Report, embracing the period 1857—1860, and dated February, 1861,* they state with reference to the latter—

"The compass errors occasioned by the more permanent part of a "ship's magnetism may be successfully compensated, and that this "compensation equalises the directive power of the compass needle "on the several courses on which a ship may be placed."

It will of course be understood that this general statement, is subject to the qualification, that magnet correction in a newly-built iron ship must not be strictly depended on, that we ought not to disregard the magnitude of the original deviation, as also that when the correction is applied to compasses having large deviations and placed near large vertical masses of iron, as a rudder, there must always be great uncertainty as to the correction on a change of magnetic latitude.

About the same time that the Liverpool Compass Committee were engaged on their Third Report, I was engaged in the reduction and discussion of the deviations observed on board all the iron-built ships of the Royal Navy, numbering among them about fifteen vessels of ordinary types that had been employed on distant stations over several years.

In a report I made to the Admiralty on this discussion, the following passage will be found: "On examination of the Tables, it is at once "observed that in the majority of examples therein given, a permanency "of magnetism exists so little affected by changes of geographical posi- "tion as materially to confirm the views entertained by the Astrono- "mer Royal in his earliest discussion (1838), that the effect of "transient induced magnetism in iron-built ships is very small com- "paratively."†

These results were opposed to the then generally received opinion, that the magnetism of an iron ship arose chiefly from transient induction; this opinion being chiefly formed on the reports of the action of compasses frequently improperly placed and corrected by those unacquainted with the principles: they were nevertheless conclusive as to the security of magnet correction for a compass placed with due care, were in unison with the experiences of the Liverpool Compass Committee, and gave confidence when the changes in naval architecture necessitated its employment.

The introduction of magnet correction for the Royal Navy, you will have now gathered was not made until the necessity arose, and a thorough investigation of the causes of past failures and past successes in its application had cleared away the doubts that prevailed: and I may here venture the opinion that had magnet correction been as indiscriminately applied in the Royal Navy as it had been in the mercantile marine prior to these investigations, we should not have had those ample records of

* In my former papers I have borne testimony to the valuable Reports of the Committee; indeed, without a careful study of these Reports, no one could presume to pronounce authoritatively on the subjects therein reviewed.

† Printed in the "Philosophical Transactions of the Royal Society," 1860, page 346.

the real magnetic history of individual ships, the discussion of which has so greatly conduced to clearing away the obscurity which hung over the subject.

Observations on the Treatment of an Iron Ship's Compasses.

In examining the numerous patent specifications relating to the mariner's compass, and which extend back to the year 1776, one is struck with the few real advantages that have been gained by the labours of inventors in this field.

The earlier patents relate chiefly to arrangements and contrivances for making observations at sea of the variation, and for modifying the motion of the ship. In 1813 the liquid compass, a real gain to the seaman, appears to have been first introduced.* In 1818 we have the first patent of an invention "to guard" or "protect" the compass needle from all action arising from iron in its neighbourhood. From about this date the patents increase in number, and of late years, notably since 1850, have somewhat rapidly multiplied.

The designs of the inventors may be thus generally classed:—

a. Mechanical arrangements applied to compass bowl or its binnacle to prevent vibration of the end, or friction on the pivot.

b. An arrangement of metals, or some presumed non-conducting substance, surrounding the compass, to prevent or cut off local attraction.

c. Self acting apparatus for registering the ship's course by compass.

d. Arrangements of auxiliary needles to detect or register the deviation.

e. Arrangements of magnets outside the compass to isolate the needle or prevent action of neighbouring iron.

f. Arrangements of magnets on the compass card to cause it to point at all times to the true north.

g. Special arrangements of cards for visibility at elevated positions, and for adjustments to meet the deviation caused by the ship's iron.

h. Methods for depolarizing or demagnetizing the iron ship's hull, in order to prevent the deviation of the compass.

i. Methods for polarizing such parts of the iron ship as may be deemed requisite to correct or prevent the deviation of the compass.

With the exception of a limited number of the more simple arrangements necessary to the mariner's compass, scarcely one of these numerous inventions are to be seen employed at the present time. The mechanical contrivances for registering the ship's course, for example, are generally remarkable for ingenuity, but fail from this cause for every day use; they give, as a rule, work for the needle to do which detracts from its directive power and consequent accuracy, at a time when these conditions are most required.

* This description of compass has been improved in later years by many well known makers, and is a necessary part of every ship's equipment.

A number of those patents relating to the "prevention or cutting off "the local attraction" have evidently emanated from minds unacquainted with the rudimentary principles of magnetism; the projectors especially overlooking the fundamental law, that the interposition of a body between the magnet and the needle on which it acts, can as little intercept the action of the magnet as the interposition of a body between the earth and another body would intercept the action of the gravitation of the earth, and also further overlooking a very obvious consideration, that if any body could intercept the action of the ship's iron it would also intercept the action of the earth's magnetic force on the needle.

In other cases, where intelligence has been displayed, the inventor has overlooked, or tried to evade—and believed he had done so—some simple but obvious law, the neglect of which produced failure.

Passing from patented inventions to the adaptations suggested by progress in scientific research, we find embodied in the Admiralty Standard-Compass many sound and elegant improvements over the compasses of olden times. In this instrument, which resulted from the labours of a Committee of well known names in magnetic science, working at the request of the Admiralty between the years 1837 and 1842; we find the application of pure copper of substantial thickness for the bowl, as being the metal next to silver known as the best conductor of electricity for quieting the vibrations of the magnetic needle —an application mainly due to the late Snow Harris. We further find the needles constructed of such a kind of steel, and on such a system as will afford the greatest directive power with little weight, a system the product of the researches of Kater, Christie, and Scoresby. Again, the pivots and caps—an all-important detail of the compass—are constructed of such materials and in such forms as had stood the best test in an extended series of experiments made by the late Captain E. Johnson, my predecessor in office, and a member of the Admiralty Compass committee; and, lastly, a remarkable arrangement, whether considered mechanically or magnetically, is to be found in the disposition of the needles on the compass card.

This arrangement and its bearings I will briefly describe. By the substitution of two or more parallel bars or needles of the compound structure adopted in the Admiralty Standard-Compass, instead of the single bar needle which was formerly in universal use, a much greater directive power was found to be obtained with the same weight. A problem then to be solved was the relative distances of the parallel bars on the card, in order that the "moments of inertia" about all horizontal axes should be equal, for if this condition was not secured, the oscillations of the card would be accompanied with a "wabbling" motion detrimental to good work.

The investigations of Archibald Smith resulted in this law, that two equal parallel bars of which the ends are 60°, or four bars of which the ends are 30° apart—*i.e.*, 15° and 45° on each side of the diameter—secured the required conditions, and this arrangement was adopted, and for many years retained, on account of this property.

But a remarkable, and at the time unlooked for property attended this arrangement of the needles on a compass card. In later years, when the employment of very long needles was getting into fashion, it had been observed that compasses in merchant ships, corrected by magnets and soft iron on the plan of the Astronomer Royal, were affected by anomalous errors; in one case, for example, which came under my own observation, these errors amounted to 5° and 6° on some points of the ship's head. To test whether these errors were caused by the length of the needle and the proximity of the correctors, a series of experiments on the deviation produced on single-bar needles of different lengths by magnets and soft iron were made at the Admiralty Compass observatory. The following results were obtained:—*

With 3-inch single needles deflected by magnets the deviations were nearly semicircular,† but with 6-inch needles, and much more strongly with 12-inch needles, a "sextantal" error of considerable magnitude was introduced.

With soft iron correctors, deflecting a long single needle, in addition to the "quadrantal" deviation, a considerable "octantal" error was introduced.

When the same experiments were made with an Admiralty card, constructed as usual with four parallel needles, the extremities of which are 15° and 45° on each side of the extremities of the diameter to which they are parallel, there was no appreciable sextantal or octantal deviation. On Mr. Smith further investigating this subject on a mathematical basis, it appeared that this arrangement of needles, as well as the simpler arrangement of two needles each 30° on each side of the diameter, produces a complete compensation and correction of these errors.

We see here the remarkable property adverted to, that the arrangement of needles which produces the equality in the moments of inertia, is by a happy coincidence, the same as that which prevents the sextantal deviation in the case of correcting magnets, and the octantal deviation in the case of soft iron correctors.

The practical result is this, that by the employment of Admiralty standard compass cards, or of cards with two needles, each 30° from the central line, correcting magnets and soft iron correctors may be placed much nearer the compass than can be safely done with a single needle card, and that the large deviations existing in iron ships may be thus far more acurately corrected.‡

Before passing from the subject of compass-needles, I would wish to offer an opinion on the employment of those large compasses fitted

* See Fig. 6, where the several curves are shown on Napier's diagram.

† *i.e.*, followed a curve of sines.

‡ To those who may be interested in this branch of the subject, I would refer to the "Philosophical Transactions" for 1861, where will be found described the whole of the experiments, together with the mathematical investigations. I believe, as resulting from this communication to the Royal Society, that the employment of double needle cards, arranged as described, is now in nearly general use.

with needles of extraordinary length, which would appear from modern practice to be considered suitable to ships of extraordinary size. I am aware that these large compasses commend themselves from the facility afforded of steering a course to degrees, instead of the old-fashioned quarter or half-quarter points; and for a certain steadiness due in one sense to the extreme slowness of oscillation in long needles as compared with short ones. There are notwithstanding fallacies and insecurity attending their use, which appear to me borne out by the facts that have come within my own knowledge of fine and well-equipped steam-ships, navigated apparently with precision and care—the course being ostentatiously steered to degrees—and still running ashore in the finest weather in some unlooked-for manner.

Now, it is well known that small magnet bars are proportionally much more powerful than large magnet bars, and that beyond a certain limit, an increase in the length of the magnet bar is not accompanied by an increase of directive power in the same proportion; so that if the thickness of the bar be preserved, its weight and consequently, its friction when supported as a compass needle is on the pivot, increases in a greater ratio than the directive power, and a direct loss of force results.

Common experience embodying this principle, has heretofore limited compass needles for use afloat to about 6 inches (the Admiralty Compass Committee adopted about $7\frac{1}{4}$ inches as the maximum length), and we may well consider that when these lengths are doubled the increased weight of the card and appendages produce an amount of friction that far exceeds the increase of directive force derived from the added length of magnet bar; the friction further is operated on at a disadvantage from the sluggishness of movement incidental to the long needle.

As a matter of opinion, I consider that the Admiralty Standard Card is as large as should be used for the purposes of navigation, as distinguished from a steering or auxiliary compass; and that as regards safety, in the long, steady, and fast ship of modern days, the choice is really between the Admiralty card and a smaller one.

Briefly to review the question of the mariners' compass. For employment in an iron ship, the chief points to be aimed at are, great directive power and susceptibility of motion; directive power in a high degree to meet the prejudicial effect caused by the earth's horizontal magnetic force acting on the soft iron of the ship, and thus seriously diminishing the mean directive force of the needle, and susceptibility of motion to overcome any tendency of the hanging up of the needle from undue friction or wear in the pivot and cap.

A compass with these attributes is invaluable to the fast ship with little motion in smooth water—conditions, be it remembered, where errors in reckoning have often proved most serious—but such a compass would probably, from its sensibility, fail when in a heavy seaway, or when subject to the violent oscillations of some of our recent ships of war propelled at high rates of speed. I certainly know of no compass that is equally accurate and effective under these diverse conditions;

and that instrument which shall be at the same time accurate and sensitively alive in smooth water, perfect in its action when pitching or rolling to the gale of wind, capable of resisting the concussion from the firing of heavy guns, and not responding to the vibrations produced by an abnormal rate of propulsion by steam, has yet, despite the long list of patents, to be invented. I may, however, I think, venture to assert that, for a combination of all that is effective under the greatest number of conditions, no compass yet projected equals the Admiralty Standard Compass. Its patient designers, with one exception,* have passed away from us, and their labours are but little known: it fell to my lot for some years in my official capacity, to be the conservator of their admirable work when exposed to the adverse influences of rash inventors and economical arguments. I am, however, now gratified to think that lengthened experience has confirmed its merits, and that, intact as I received the Admiralty Standard Compass, so will it remain for our successors, unless, indeed, some master-mind appears to give it those attributes which eager, but, I think, unreflecting minds consider it ought to possess.

I have now passed in review the chief points connected with my subject, which appeared to me to deserve your attention; there is, however, an incident that may be considered to claim attention, from the circumstance that it created much discussion in this Institution. I allude to the "de-polarizing" or "de-magnetizing" process of the late Mr. Evan Hopkins, for rendering correcting magnets or deviation tables unnecessary, by destroying the polarity acquired while the ship is building; and which was applied to Her Majesty's ship "Northumberland." As I have already, in a paper read before the Royal Society, and published in their Transactions,† given my opinions on this proposal and the numerical data on which those adverse opinions are based, I should not, as an incident of progress in magnetic science applied to navigation, have alluded to it here; but, as the proposal has been recently revived with a vigour of announcement and assertion of practical utility scarcely surpassed by the clever but sanguine original projector, I will detain you a few moments by reading brief extracts from the paper to which allusion has been made bearing on the failure of this unsound proposal, as also the condemnatory opinions expressed thereon.

I state, as proved by observations made in ample detail, of the kind I have brought to your notice, and very thoroughly discussed numerically and graphically, "that the process"—(which, departing from the terms of the patent specifications resolved itself ultimately into rubbing the beams and iron stanchions near the compasses with powerful electro-magnets),—"is not one of general de-magnetization, "but of partial counter-magnetization, and results in an irregular dis-"tribution of magnetism of very variable intensity, necessarily very

* General Sir Edward Sabine, K.C.B., late President of the Royal Society, and Chairman of the present meeting.

† For 1868, pages 487–508.

"unstable, and producing, wherever effective, a rapidly varying field "of force.

"That so far from the process being in any sense of the word one of "'depolarization,' either of the whole ship or any part of it, it was, on "the contrary, the 'polarization' to a high degree of intensity of a "particular portion of the iron in the neighbourhood of three of the "compasses." That "the iron so magnetized was iron capable of re- "ceiving only sub-permanent magnetism, and which, from its forming "part of the structure of the vessel, was subject to strains and concus- "sions from which detached magnets are wholly free. The magnetism "so communicated was, therefore, necessarily unstable and transient, "and, from its liability to change suddenly and unexpectedly, was a "source of danger to the vessel.

"Nor would the effect produced, even if it had been much more "permanent than it proved to be, be considered an advantage. In two "out of the three compasses to which it was applied . . . the re- "quisite reduction might have been effected with infinitely greater ease "and certainty, as well as permanency, by the application of a single "magnet to each compass."

Let us, however, in conclusion, pass from the consideration of matters unpractical and unsound to those based on secure foundations. On a review of what in this lecture I have brought under your notice—I fear in a somewhat fragmentary and imperfect manner—the question may be asked, how far has this knowledge extended, and how far has it aided the navigator? The reply, so far as I am aware, is generally satisfactory. Foreign nations interested in maritime affairs have unhesitatingly adopted the principles and the practice of the Royal Navy; their handbooks are all based on our own Admiralty Compass Manual. America, with her iron monitor fleet, having felt the necessity of establishing a Compass Committee of Inquiry some few years back, her Bureau of Navigation at Washington has collected in two volumes, in the interests of the "naval service, and, indeed, of all intelligent navigators," the various theoretical and practical investigations embodied in papers contributed by our countrymen to various learned societies from the time of Poisson's Memoir, to 1866. The preface to the first of these volumes states that "the English investiga- "tions on compass deviation, while eminently practical, have steadily "advanced towards establishing a comprehensive and available theory "in all that relates to this subject."

In our own mercantile marine an impetus to extended knowledge has been lately given by the Board of Trade. Masters, in order to obtain an extra certificate of competency, must pass an examination in our subject—the opportunity has been afforded me of inspecting the examination papers of a few successful candidates, and I found them stamped by a sound practical knowledge of principles and details—highly favourable to a more perfect system of "compass-adjustment" in our merchant ships of the future. The ordinary examination of masters and mates also with the present year embraces the methods of ascer-

taining and applying the deviation of the compass, the knowledge of which is equally necessary with the calculation of a day's work.

In the Royal Navy, though magnetism as a branch of nautical education has scarcely yet taken root, we have a few Officers well trained in its principles and practice as applied to navigation. This small band of experts, it is to be hoped, will be steadily kept up in the interests of the service. The fact is also assuring, and speaks well for the care and skill of our navigating Officers, that within the last twenty years, so far as I am informed, no misadventure has happened to a British ship-of-war through default of her compasses.

In the interests of navigation—and I say this with pleasure in the presence of one of our greatest masters in magnetic science, and to whom the Royal Navy and myself personally owe many debts of gratitude, I allude to our eminent Chairman—I confidently look forward at no distant date to magnetism in its several divisions occupying a fair share of the attention of naval Officers, not only as a necessary branch of education, but as an intellectual study that carries with it an indescribable charm, and is of a high order for estimating and grasping the more secret workings of nature.

Evening Meeting.

Monday, February 5th, 1872.

GENERAL SIR WILLIAM J. CODRINGTON, G.C.B., in the Chair.

NAMES of MEMBERS who joined the Institution between the 30th January and the 5th February, 1872.

LIFE.

Warre, Rev. Edward, Captain, 8th Bucks Rifle Volunteers.
Spratt, Fredk. T. N., Lieut., R.E.
Moreton, Augs. H. M., Captain, Coldstream Guards.
Charteris, Hon. Alfred W., Lieut., Coldstream Guards.

ANNUAL.

Bailey, Vincent, Captain, Herts Militia.
Thorold, Cecil, Captain, 1st Life Guards.
Murray, C. A. Scott, Lieut., 1st Life Guards.
Gillett, W., Captain, Uxbridge Yeomanry Cavalry.
Clayton, W. L. Nicholl, Captain, Isle of Wight Artillery Militia.
Sulivan, G. L., Captain, R.N.
Rossmore, H. C. W., Lord, Lieut., 1st Life Guards.
Cavenagh, Orfeur, Major-General, Bengal Staff Corps.
Cavenagh, Gordon, Colonel, Bengal Staff Corps.
Cumberlege, H. O., Captain, Bengal Staff Corps.
Baker, F. M., Lieut., 1st Royal Cheshire Mil.

THE CONTROL SERVICE; WITH PRACTICAL SUGGESTIONS FOR ITS IMPROVEMENT TO MEET THOSE DEFECTS WHICH TWO YEARS' EXPERIENCE OF ITS WORKING HAVE EXHIBITED.

By E. B. DE FONBLANQUE, Esq., Deputy Controller H.P.

WHEN nearly three years ago I had last the honour of reading a paper in this room, I endeavoured to describe the nature of the great change in our system of Army supply then in course of progress, as the consequence of the suggestions contained in the Report of the Royal Commission, under the presidency of Lord Strathnairn. After long and careful preliminary arrangements on the part of the War Office, the new system was started in the beginning of 1870, and the experience of two years now enables us to form a fair estimate of the practical result.

Now, we all know the proverbially disproportionate value of theory and practice, and how wide a divergence experience is apt to

trace between the idea as conceived, and the creation which springs from it. It need not, therefore, be a matter of surprise that the Control system, when it appeared in the flesh, differed very considerably from what it was in the spirit, and that, when practically tried, it fell short in some important points from what was contemplated by its authors and advocates. Lord Strathnairn's Committee was composed almost exclusively of military Officers, and their report was received with favour by the Horse Guards; but when the scheme came to be manipulated by the War Office, and "Control" was finally launched, the result was not at all what was expected, and the military authorities were in the position of the hen who, after careful incubation of what she fondly supposes to be her own eggs, finds that she has produced a web-footed brood, who, instead of nestling under her wing, take to an element quite foreign to her tastes and nature.

I confess that I greatly regret this divergence from the original scheme; I am inclined to believe that the defects discovered in the working of the new system may be mainly traced to this cause, and that had the War Office adhered more closely to the principles as laid down in the Report, Control would have been rendered more acceptable to the Army, and therefore more conducive to the interests of the public.

Fortunately, the experiment has been tried under the favourable circumstances of a period of peace, and it is well for us that we have had ample opportunity of testing the new system without incurring any serious risk to military efficiency; and that we are enabled, not only to find out weak points, and to trace the causes of weakness whenever it is discovered, but to apply at once such practical remedies as experience may suggest, to remove a superfluous wheel here, to strengthen the machinery there, and gradually to bring the whole system into such working order as shall render it fit to bear the strain and shock of war. The remarks I am about to make, are intended to facilitate this end; and if, in the course of my observations, I should appear to dwell overmuch upon the defects, and not sufficiently upon the merits of "Control," let me plead that I do so in the most kindly spirit, as dealing with a thing, in the origin and development of which I bore a part, however humble, and in the honour, success, and welfare of which, I shall ever take the warmest interest.

I may remind you that the gist of Lord Strathnairn's Report was a recommendation that the various existing departments charged with the supply of provisions and warlike stores, with the direction of transport, hospital, and barrack arrangements, and with the control and detail of finance and expenditure, should be amalgamated, and formed into one Executive Department, and that a staff of officers, specially selected for the purpose, should be placed at its head, to direct and administer the various services in concert with, and in strict subordination to, General Officers in command. I will now proceed to show you what has been the result of this recommendation.

The Administrative Branch of the new service is composed of 57 officers, of whom 26 are members of the old Commissariat, 15 of the Military Store, 4 of the Purveyors, and 2 of the Barrack Departments;

in addition to these there joined on probation, one Lieutenant-Colonel of the Royal Engineers, one Lieutenant-Colonel of the Military Train, and 8 Captains or Majors who had passed through the Staff College.

The Executive Departments are composed of 340 Commissaries and 70 Paymasters, there being three ranks of each. These have been drawn from various sources, including Commissariat and Military Store Officers, Barrackmasters, Purveyors, Officers of the Military-Train, Subalterns of the Line, War-Office clerks, and non-commissioned officers from the Army-Service-Corps, the Military-Train, and the Line generally.

The old Commissariat Staff-Corps, Military-Staff-Corps, and Hospital-Corps have likewise been amalgamated under the unmeaning title of "Army-Service-Corps" (Army Supply Corps would have been a much better name) and two Assistant-Controllers and 50 Commissaries are detailed for the officering of this body, which consists of 2,514 non-commissioned officers, rank and file, and is divided into two sections, the one furnishing transport of every description, and the others providing clerks, artificers, mechanics, and the various tradesmen and labourers necessary for purposes of Army supply.

Under the old system, each Department required its distinct representative in every garrison, quite irrespective of the extent of duty to be performed; but now Commissaries are supposed to be generally available for the performance of any supply service that may devolve upon them, whether in connection with provisions, warlike stores, transport, hospitals, or barracks. Among the older Officers who have passed the best years of their lives in one particular branch, it has not been found expedient to carry into effect this part of the scheme, but among the juniors it has been introduced with the best effect, and with a very great economy of labour, as strongly testified by Sir Garnet Wolseley, with reference to the "Red River Expedition," the only occasion upon which Control has been practically tested on active service. The force employed upon that expedition was a small one, but the difficulties to be overcome were of an exceptionally formidable nature, owing to the badness or entire absence of roads, the condition of the country to be traversed, and the length of the line of communication necessarily maintained. The success of the Control arrangements was due in a great measure to the fact, that the Controller was a man thoroughly qualified for his post and in the full confidence of his Commander; but I am disposed to attribute no small portion of it to the circumstance that the Red River was a long way from the War Office, a circumstance which made it impossible to impair the efficiency or weaken the responsibility of the General or his Controller by officious interference. Given a good Controller, knowing his work and not fearing responsibility, and I will venture to say that his success will bear an exact proportion to the distance which separates him from Pall Mall, and the greater or less degree of confidence reposed in him by his General. I believe that most of the failures in the new system will be found to bear reference to these two conditions.

One of the grounds upon which the amalgamation of Supply Departments recommended itself to public favour was, the pecuniary saving

which it promised to effect, and it may not be out of place if I here show you by a comparative statement of the cost of the two establishments, how far these expectations has been realized. My figures are taken from the Army Estimates for 1867–68 and 1870–71, and though not perhaps quite accurate, will be found sufficiently approximate to the actual expenditure to answer the purpose of comparison :—

Comparative Statement—Estimates 1868–69 *and* 1871–72.

Numbers.	1868–69. Old Systems.	£	Numbers.	1871–72. New Systems.	£
206	Commissariat	86,861	57	Controllers	31,753
97	Barrack	21,195	340	Commissaries	80,254
85	Purveyors	18,000	70	Paymasters	19,082
184	Military Store	50,130		Subordinates	21,469
				Wages, including working pay	161,134
	Corps.				
601	C. S. Corps .. (including clothing)	23,366	2,514	Army Service Corps..... (including clothing)	99,769
400	M. S. S. Corps (including clothing)	16,414			
1,004	A. H. Corps* (including clothing)	33,190	1,000*	Army Hospital Corps .. (including clothing)	31,834
1.798	Military Train (including clothing)	79,790			
	Subordinates.				
	Commissariat (including working pay)	33,838			
	Barrack .... (including working pay)	32,482			
	Purveyors .. (including working pay)	9,162			
	Military Store (including working pay)	117,101			
4,375	TOTAL	521,524	3,981	TOTAL	445,295

Shewing a difference of £76,229 in favour of the new system, which, in a financial point of view, may thus be considered a success.

Having shown you what the "Control Department" *is*, I shall now proceed to tell you what it *does*, or what it is supposed and expected to do; before going further, however, I wish to express my concurrence in an objection largely shared throughout the Army to the name of "Control" and "Controller," more especially as applied to the Executive Departments. That the directing body of Officers placed at the head of the "supply services" should bear that name is intelligible, for their peculiar function is control over the expenditure of money and stores, and the various duties therewith connected, and as far as they are concerned I see but one objection to this title, and that is, that it conveys a certain assertion of supremacy and superiority quite incompatible with that subordination to military authority without which the system could not endure for a day; but

* These figures comprise the whole of the A.H.C. Purveying and medical branches have not yet been divided.

to call the Executive Department, "Control Department," or the Executive Officers "Control Officers," is about as sensible as if we were to call the Volunteers the "Inspection Corps," because there is a body of Officers appointed to inspect them. Oddly enough, while in the smallest garrison there is some agent calling himself a "Control Officer," the Head of the Department at the War Office, by his title disassociates himself from control altogether, and is called Surveyor-General of Ordnance, which is much as if the Commander-in-Chief were to drop his claim to General Command, and call himself Surveyor-General of Cavalry. These objections may appear trivial, but practically names count for a good deal in the Army, and it is of real importance that no Officer should bear a title which conveys a false impression of the functions he performs.

This brings me to another feature of the same subject. There has been a good deal of discussion as to the propriety of extending titular Army-rank to the Controllers, and their subordinates, and the question is one involving much more than personal considerations, and admitting of a good deal of argument on either side. I have just said that a title should be as far as possible indicative of the duty, and to propose calling a Controller or a Commissary, Colonel or Captain, may appear inconsistent with that opinion, and yet I am not quite prepared to give up the point. The existing "Control Department" is in all its branches largely recruited from Military Officers, and comprises a corps formed of enlisted soldiers, equal in numbers to four Infantry battalions, and which, although not employed on combatant duties, requires to be as strictly disciplined, as carefully drilled, and as much maintained in military order and subordination, as any regiment in the service. Controllers, and their subordinate Officers are, as regards their immediate branch of the service, invested with the same command as Regimental Officers; they sit on Courts-martial, and they take precedence according to their relative Army-rank. There certainly is something anomalous in such a state of things, and though I, speaking for myself personally, should have felt myself in a very false position had I, after being called Mister for thirty years, found myself suddenly dubbed Colonel, I am by no means sure that military rank (command being strictly limited to the Department) would not prove beneficial as far as the public interests are concerned, by strengthening the hands of authority and facilitating the maintenance of discipline. The soldier is a creature of habit, and it must puzzle him, and rather confound his ideas of right and wrong, to find the Captain of his company, and even the Officer at the head of his brigade (who by the way was a full Colonel in command of a distinguished corps before he became Controller) bearing a civilian designation. I am not insensible to the difficulties which beset this question, but now that the "Control" staff is in a great part drawn from the military staff of the Army, it becomes a very pertinent matter to consider whether it were better for the public interests to convert these soldiers into civilians, or to convert the civilians into *quasi* soldiers. I have no hesitation in stating my opinion that in drawing a proportion of our recruits from the Staff Officers of the Army, and thus bringing not only military experience, but high

educational attainments to bear upon questions of administration, the Control Service has greatly strengthened itself; I will go further and state, that if it would have been practicable (and I believe the difficulty of such a course was more apparent than real), to have swept away the superior Officers of the old Supply Departments, and formed the Control Staff exclusively of qualified Staff Officers, the system would have worked much better than it has done, and would have been at once brought into complete harmony with the Army generally. I do not stand alone in this opinion, and may take this opportunity of mentioning that one of our ablest and most efficient Controllers, on being appointed to the charge of a very important post, suggested, with a public spirit and disinterestedness worthy of all praise, that the appointment should be conferred upon the Quartermaster-General on the station, rather than upon him, feeling sure that the new system would thus have a better start; and he offered, in the event of his suggestion being complied with, to serve under that Officer and afford him the benefit of his departmental experience. He knew the value of military rank in any position involving intimate contact with the different branches of the Army. Doubtless many Control Officers will entirely differ from me, and indignantly refute my views; "What," they will say, "what can a military staff-officer know about 'finance' and 'supply,' and 'transport,' and 'account' and the various duties devolving upon Controllers?" To this I will reply, that a good Quartermaster-General, through whose agency all supply-services were formerly conducted, who was the medium of all departmental correspondence, and actually, though not nominally, the local referee upon all questions relating to supply services, should have acquired a greater *general* knowledge of administration than the members of any one of the old departments, whose experience was necessarily restricted to his particular branch. Without wishing to exalt the immediate service to which I myself belonged for many years, I may venture to say that a Commissariat Officer's field of duty, comprising as it did not only the provisioning of troops in all branches and under all circumstances, but the conduct of large financial and monetary operations, the organisation and direction of transport and the formation of contracts for all army services, afforded a better training for the general duties of a Controller than could possibly be possessed by other departmental officers, whose duties confined them to a more restricted field, such as the receipt and distribution of warlike stores, the interior economy of a hospital, or the custody of barrack buildings. Yet, I assert that, with all his superior qualifications for the exercise of administrative supervision, the best Commissariat Officer would not in his capacity for general control be superior to the best Quartermaster-General. The latter, it is true, might be, and in all probability would be, ignorant of finance in its higher branches, and of details upon other points; but this deficiency exists equally in three of the four Supply Departments which furnish Controllers, and would be compensated for by more extensive administrative knowledge acquired by contact with several departments instead of with one only; by the practice of organisation

inseparable from his position; and, last, not least, by his military training and experience and (presuming him to have passed through the Staff College) his high educational acquirements.

The system of appointment to the Control Department is curious when it is considered how much of the success of the experiment depends upon individual qualification. As a rule, every superior Officer who by dint of service had attained a certain position in the late Commissariat, the Military Store, the Purveyors, or the Barrack Department, was, if not notoriously disqualified, promoted to be a Controller, and that system prevails to this day; the seniors of the old services stepping, almost as a matter of course, into the new and greatly extended position. Now, I admit the difficulty of the case. With a number of men of different departments proclaiming their merits, clamouring for their rights, and bolstering up their claims by whatever private or political influence they could bring to bear, it was perhaps the easiest course to make seniority the rule; it saved trouble and heartburnings, and the authorities escaped the suspicion of partiality or favoritism, though in some instances at the expense of the public interests. But then the question naturally occurs, "Why exact from military candidates the highest educational test known to the Army, while departmental candidates are subject to no test whatever?" I shall be told, "in order to compensate for the want of technical knowledge;" but I have already shown that this technical knowledge on the part of departmental officers is, as a rule, limited to one branch of administration, and as military candidates are required to serve for two years on probation, during which time they can practically acquire a thorough knowledge of each branch,—they start, even in this respect, with some advantage over the average departmental officer. Now it appears to me quite clear, that either we exact too much from the military or too little from the civilian Controller, and I incline to think that the latter is the case, and that if the present system of mixed appointments continues in force, that every departmental officer should be subjected to an examination of a character which will ensure his equality, as a man of knowledge and education, with the officer who has passed through the Staff-College.

I do not hesitate to say, that although there are other causes at work which have hitherto impeded the successful working of the Control scheme, that the indiscriminate appointments of men possessed of no qualification for the responsible post conferred upon them, has been a great stumbling block. Financial considerations had, I doubt not, to be consulted in these appointments—but it is a very false economy to promote a man to a higher post simply because he served respectably in a lower one; and the course pursued in the limited sphere of the Control appointments does not inspire one with much confidence in the future, now that the wide field of Army promotion is to be regulated with reference to fitness rather than seniority. Seldom perhaps has a great change been conducted with so little favouritism or partiality, as the amalgamation of War-Office-Departments, but I am sure that the timid and respectable course pursued has proved more mischievous than bolder tactics would have done, even though

tinged with a certain amount of jobbery. In time of peace, no more serious mischief is likely to arise, even from an incapable Controller, than a loss of departmental credit and prestige, and occasional inconvenience to the troops; but the case would assume a much more serious aspect, if men possessed of no higher qualification than a respectable knowledge of one branch of supply-duty acquired at their departmental-desks, had to be entrusted with the Control charge of a body of troops in the field, in time of war. During the late Autumn Manœuvres, some of the Supply Officers had to be relieved from divisional duty because they did not know how to mount a horse, or having mounted it, how to retain their seats, and I am by no means sure that this and greater shortcomings would not be discovered in some of our Controllers, to whom an arm-chair is more congenial than a charger, and who have been advanced to a greatly extended position of responsibility, and an entirely new sphere of action, simply because for a long series of years they conducted themselves with propriety as clerks or accountants.*

The questions I have raised as to the extension of military rank to the members of the Control services, the expediency of making it a purely military, or a more purely civil department than at present, the system of promotion by seniority from the Supply Branches and other points connected with the subject, appear to be matters fairly open to discussion, upon which I should be much pleased to hear the opinions of some of my audience.

At the risk of becoming tedious, I must once more beg to call your attention to the Strathnairn Report, which was the corner-stone of the present edifice, however much the fancy of the architect or the shortcomings of the builder have altered its original character and the leading principle of which is "a better division of labour, and a greater concentration of responsibility." Any one who will read the report with ordinary care will note how steadily that principle is kept in view throughout the various and multitudinous details which are necessarily discussed. The Commission was formed of practical men, thoroughly conversant with the wants of the service, and who endeavoured to remedy the existing waste of power, and confusion and extravagance, and to devise, by the light of their experience, a simple and intelligible system of Army Supply. What they said was in effect this:—"Here we have in every garrison at home and abroad some half-"dozen departments playing at cross purposes with one another at the "public expense, each directed by its own distinct head, acting under its "own distinct regulations, and corresponding directly on local matters "with its own distinct chief at the War Office. Let us remedy this state "of things by placing all these departments under the local direction of "one man, with a view to united instead of divided and antagonistic

* It is told of Sir James M'Grigor that, great pressure being put upon him while he was at the head of the Army Medical Department in favor of a notoriously ignorant man who was a candidate for the post of Regimental Surgeon, he finally yielded to the importunities of his friends, and conferred the appointment, upon condition that the young man gave his word of honour that he would never, under any circumstances, administer any medicine except Epsom Salts. Sir Henry Storks would, in the event of a war, have to impose similar restrictions upon some of his Controllers.

"action, and placing that one man under the General in local command "as his adviser, agent, and mouthpiece on all matters of finance and "supply. The troops will thus be better served, the General Officer "will be relieved of a mass of detail and correspondence which now "occupies so much of his time, and the public will save money." This was a practical common sense view of the question, with a logical solution in the shape of the Control scheme for its result.

Now, had it been possible to have left the practical development of the scheme to the same body as that which originated it, I have no doubt "Control" would by this time have been in a very different condition from what it is, but the Commission had completed their task when they signed the Report; like a jury in a court of justice, they gave their verdict, and it was for another agency to pass and to execute the sentence; and here I must beg of you, to bear in mind the very peculiar condition of our institutions in respect to the administration of the Army, and that dual government of which so much has been said of late years, and which, in the opinion of a very large number of well-informed people, is supposed to be of modern date, and consequent upon the establishment of a War Ministry. I think, however, I shall show you that this antagonism between the civil and military element is nearly as old as the constitutional Army itself. It is now nearly 200 years ago—the Act is dated 1676—that a Parliamentary officer was appointed to watch and control military expenditure on behalf of the House of Commons; and in a very remarkable State paper drawn up by Lord Palmerston (and appended to Sir Henry Bulwer's Life of that statesman) you will read how, during those two centuries, successive Commanders-in-Chief habitually presented and resisted this restriction upon their authority. Just 60 years ago, in 1812, when Lord Palmerston was Secretary at War, and Sir David Dundas Commander-in-Chief, there was an open conflict upon the rival pretensions of these two officers, the latter complaining of the gradual encroachments of the Parliamentary element as derogatory to the dignity of the Commander-in-Chief and subversive of the discipline of the Army, while the former asserted his right to control military action and to form, as he expresses, "a sort of barrier between the military officer in command of the Army and the civil rights of the people."

Now, in a political point of view, the struggle was virtually ended by the appointment of a Cabinet Minister supremely responsible for the efficiency of the Army, but you cannot abolish the traditions and habits of ages by an Act of Parliament, and as long as the Secretary of State for War is, as he must as a rule be, a civilian incapable of assuming military command, and therefore compelled to delegate it to another, so long will the military element refuse to be completely merged in civil administration. Circumstances may modify the power of the resistance, and mutual tact and judgment may so far soften the asperity of opposition as to produce a working compromise—but the arm which actually wields command, will always be the stronger arm in the opinion of military men, and the soldier, no matter whether he be a private or a general, will never be brought to entertain the same sentiment of

personal respect and deference for a political agent, no matter how highly placed, as he would for a military commander. While such feelings exist (and after all they are almost inseparable from a true military spirit) so long will there be antagonism in the government of the Army, and so long will the complete subordination of the Army to civil authority continue to be a political theory only. The broad distinction between our system and that of Continental Armies lies in the fact, that, with them, the War Minister is also Commander-in-Chief, subject only to the will of the Sovereign,and as a rule a distinguished General, chosen for large and varied experience in every branch of the Service, capable of entering into the feelings of the soldier, of understanding his wants, of identifying himself with his interests, and equally versed in the art of war and the science of administration. We might possibly find Generals possessed of all these qualifications—there is no reason why the Prussians should have a monopoly of such men as Moltke and Von Roon, nor do I believe that they have—but it could only be by a most rare and extraordinary combination of circumstances that such a General should possess the political training, experience, and influence which alone could obtain for him admittance into the foremost ranks of political life, and thus, although a professional War Minister might prove the means of solving a serious difficulty, fulfilling at once constitutional obligations and military requirements, such a thing is barely within the bounds of possibility, and we must therefore make the best we can of existing conditions.

I must apologise for this apparent digression, but the actual relations between War-Office and Horse-Guards have a material bearing upon the subject of my lecture.

No sooner was the Strathnairn Report in the hands of the War-Office, who knew that its suggestions met with the approval of the Horse-Guards, than they took alarm at what they chose to consider military encroachment upon the constitutional province of the Secretary of State. The leader in this attack was a gentleman then holding a high position in the War Office, but now removed to a less stormy sphere of public usefulness, a gentlemen of very superior ability and for whose character I have the greatest respect, however much I differ from his opinions. Well, he denounced the scheme as fraught with danger, not to the Army—that was always with him, and the branch he represented, a secondary consideration—but to the War-Office and to the public purse, and when Sir Henry Storks and General Balfour were appointed to consider and report upon the best means of giving practical development to the plan, the opposition increased ten-fold. Now, Sir Henry Storks is, as we all know, a very distinguished administrator, who for the last twenty years nearly has been employed in high civil duties, and General Balfour is well known for the part he had taken in connection with financial reforms in India; but both these gentlemen happen to be soldiers as well as administrators, and so the War-Office saw in them that small end of the wedge which alarmists are always discovering, and resisted them as zealous gamekeepers would resist trespassers upon their preserves. I dare say some of my audience may remember how these apprehensions found an echo

in two influential newspapers at that time, and how the "Pall Mall Gazette" and the "Saturday Review," in flourishing leaders, proclaimed the imminent peril to which the Constitution was exposed by "the Horse Guards' Plot," and how General Officers, with the aid of Controllers, were going to usurp the functions of the War Minister, play at "ducks and drakes" with the public money, and dragoon the House of Commons.

This is, I assure you, no exaggerated statement of the arguments used. I do not know whether these newspapers gave their tone to the War-Office, or whether the War-Office inspired the newspapers, but the two agreed in this line of opposition to the progress of the Control scheme, and not without effect. It must be remembered that decentralisation was one of the prominent features of the new plan, and that decentralisation meant the transfer of a great deal of business from the War-Office, to local agency in every garrison or district at home and abroad. Now, whatever tended to reduce labour, tended to reduce establishments, and if the appointment of Controllers involved the dis-establishment of War-Office Clerks, why, making allowance for human nature, it need not be a matter of surprise that the threatened officials cried out very loud and used all means to prolong their existence.

But the authorities were committed to action in the direction of "Control"; it was impossible to burk Lord Strathnairn's Committee; on the other hand, the opposition was formidable. Might not a compromise be effected by establishing nominal Controllers, but giving them nothing to control, and leaving the power and action of all branches of the War-Office intact? Some such idea probably arose; at any rate, by the time the scheme took shape, it was so altered that its originators were unable to recognise their offspring, and the military authorities, who had seen in the plans of the Royal Commission a practical measure beneficial to the soldier, could now only discover a huge machine, calculated as they thought to weaken the responsibility and lower the dignity of military authority. The poor Controller thus found himself between two fires, the War-Office considering him a poacher in the military interests, prowling about to find an opening into their covers—the Horse-Guards looking upon him as an officious, meddlesome fellow, anxious to carry War-Office pretensions into every garrison, and to swagger before General Officers in the name of the Secretary of State. It was not a pleasant position to start from, as I can testify from personal experience, when I was first appointed to establish the new system in a Home District, and as my case was that of most others, I may quote it as a fair example. In the first instance, I applied for instructions, but no instructions had been prepared; I would arrange matters for the best in concert with the General in local command. Well, this was at any rate flattering, as it left much to my discretion and invested me with a degree of responsibility, which at once gave me an exceptional interest in my work, so I joined my station and found a General who gave me a cold shoulder, a Staff who treated me as an interloper, a garrison who did not know what I was and why I came there, and the usual number of "Supply Departments,"

smarting at the loss of their independence, and not too well disposed to pull together in the new team with a strange coachman on the box. Personally, I had certainly no reason for complaint, and I was on friendly terms with all, but I could not help feeling that nobody wanted me in my official capacity, and that the only support I had to expect in my task was from the War-Office. I made a mistake there. My General was too thorough a soldier not to afford me that recognition which his duty required of him; but he did no more, and if a Staff Officer had met with such an official reception from the Chief to whom he came to be attached, he would have been much tempted to resign his appointment. It was impossible for me not to become aware that I was viewed with suspicion, that confidence was withheld from me, that my opinions were not likely to be consulted, and that when offered, they were very likely to be disregarded. It is not easy to break through old habits; and it was not without an evident effort that the General, in obedience to instructions, allowed me to supersede his accustomed Staff-Officer in the transaction of administrative duty, to obtain and convey his decisions directly instead of through the former channel, and to deal with matters which hitherto had been considered as falling within a purely military province. Staff-Officers were equally unwilling to cede any portion of their accustomed privileges, and Commanding Officers of regiments did not all approve of carrying their complaints and grievances with regard to finance or supply to the Controller direct instead of to the Quartermaster-General. However, every new system has its difficulties at first starting, and the time will come, I thought, when the General will find out how much trouble a Controller may save him; I soon discovered how powerless I was, and in illustration of the actual system, will quote one case. A claim was made on behalf of a small body of troops for a trifling allowance to add to their comfort under exceptional circumstances; under the old system this would have involved considerable delay and long correspondence, as happened once to my knowledge when an application for additional fuel on account of a very severe winter was not finally granted by the War-Office until the dog days were setting in; but "Control," if it means anything, means local decision on such points, so when the General expressed a strong opinion that the claim was a just one, the Controller concurred in his view, and ordered the issue, reporting to the War-Office what had taken place, and feeling rather proud of this practical proof of the advantages of "Control;" when lo! back comes a Minute disallowing what had been done, and surcharging the Controller with the value of the issue. It was from such cases that I soon learnt, what has since become generally known, that neither a General nor a Controller has the power to authorise the issue of anything not provided for by regulation, and that if they presume to do so, from mistaken feelings of interest in the comfort of the soldier, they must take the consequences. Such cases as the one I have quoted, are not calculated to improve a Controller's position; instead of helping the General, he had caused him to be snubbed, and his confidence in the Controller was more than ever shaken. Now, I would not cite such an instance were it not that, to my certain knowledge, it is laid down as

an absolute rule, that neither the General nor the Controller on a Home Station has the power to carry any measure, however urgent or beneficial, without first obtaining the authority and approval of the War-Office, and, as in many of these cases the circumstances upon which exceptional claims are founded, are of a nature which a War-Office clerk, ignorant, as he necessarily is of local and military detail, cannot appreciate, it frequently happens that the comfort of the soldier is sacrificed to this stupid adherence to red-tape and the cause of clerkdom.

Now, if a Controller is allowed no discretion, why does he exist at all? According to the spirit of the Report, which I take for my text, the General Officer in command is supreme, and the local representative at once of the Commander-in-Chief and of the Secretary of State. He has at his right hand his military Staff-Officer to assist him in discipline, at his left, his Controller to assist him in administration; but under present arrangements the General, though allowed a wide discretion by the Horse-Guards, is allowed no discretion whatever by the War-Office. By the former he is entrusted with the efficiency, the health, the comfort, and the general welfare of thousands of soldiers; by the latter he is virtually prohibited from ordering the expenditure of sixpence, the issue of an extra bushel of coals, or of an ounce of bread, even though their own agent should fully concur in its necessity. The War-Office is reluctant to entrust power to an agent of the Horse-Guards, so they place at his side an agent of their own; but lest he again should fall under military influence, or usurp, or weaken central-authority, they place over him an agent of the War-Office, without whose approval, previously obtained, local action is invalid. So we have local Controllers with nothing to control, and local Paymasters with nothing, or next to nothing, to pay; the corresponding branches of the War Office assuming all their responsibility and undertaking nearly all their duties in order to justify their official existence, the necessity for which I very strongly doubt. We have thus double "Control-Establishments,"* involving much correspondence, delay, and expense—*diluting responsibility*, which it was the great object of the Control scheme to strengthen, and *strengthening that centralisation* which it was its aim to destroy. If local Controllers are not to be trusted, abolish them, and let War-Office-clerks, in Pall Mall, do their work; but let this be done openly, so that we may know where responsibility is due, and do not let us keep up the show of Control in every garrison, and the reality of it at every War-Office desk.

I now come to a point upon which much diversity of opinion prevails both within and without the Department. Under the old system, the custody of warlike stores was entrusted to what was formerly called the Civil Branch of the Ordnance, and ultimately became the Military Store Department; but as the members of this Service were

* An experienced Controller states, that were war to break out, the first duty which the War-Office would impress upon him would certainly be the collection of those innumerable and various printed forms, which have been invented apparently for no other purpose than to afford gentlemen in Pall Mall occupations and a pretext for interference in matters of executive detail.

as a rule, devoid of scientific knowledge, Artillery Officers were appointed to act as Inspectors while they were the Custodians of warlike stores; this professional element has now been withdrawn, and the whole duty connected with Arms and Ammunition, excepting their manufacture, has fallen within the province of Control. I speak from experience when I say that Controllers are as a general rule, unequal to the direction of these duties; I certainly felt myself in a false position in this respect, and had either to talk about things which I did not understand, or own my ignorance, and consequently, in so far, my unfitness for my post. I believe others have found themselves in the same predicament, and that the majority of Controllers are satisfied that the administration of Warlike Stores should devolve upon a special staff, to be attached to the Royal Artillery. Here again, probably, the civil element will step in with its veto; but surely if the War-Office can entrust the direction of ordnance manufactories, with the large expenditure they involve, to Artillery Officers, they might in like manner entrust to them the administration of the stores when manufactured, under such restrictions and regulations as they should consider necessary. The non-warlike stores, indeed everything not coming under the head of "Ordnance," should remain in charge of the Control Department, and such a division of duty would be easily carried out, since in reality there is no connection between the Ordnance Branch and the Supply Services, the so-called Controllers of Arsenals performing no general Control duties, and the old Military Store Branch under its distinct head continuing intact at the War-Office. I should be very glad to hear this question discussed, knowing that much may be said on either side.

A few words on the Army Service Corps, which requires reform, though its defective working is less due to inherent faults, than to that *centralisation* and War-Office meddling in executive detail, which proves so fatal to the branches of the Control Services.

It is an understood thing that a General Officer is responsible for the working condition not only of the men but of the horses within his command. Were the Commander-in-Chief on an inspection to find the horses of a cavalry regiment or of a battery of field-artillery in bad order, he would "pitch into" the General, who might in his turn "pitch into" the Commanding Officer, but to whomsoever the blame should be attached, it would necessarily be to some local authority. Now the Army Corps service is according to regulation, in all that regards discipline as much under local military authority as any battalion of the line, and like other corps, is periodically inspected by the General Officer. Let us suppose such an Inspection, and I am going to cite an actual and not a supposititious case. The General says to his Controller, "I don't like the condition of the transport horses—they are too poor; they have hard work, and you ought to have applied to me to sanction the issue of extra forage for them." "Very true, Sir," says the Controller; "but the War-Office have decided that they were not to have extra forage for the next six months"; or, as also happened:—"Don't let me see your waggons carrying heavy loads with only two horses—it's cruelty to animals!" "So it is, Sir," says the Controller, "but the War-Office has strictly

forbidden me to employ four horses under any circumstances." Well, I will not say what would be the answer of many a General; his remark upon the War-Office would probably be short and emphatic;—but how, let me ask, can local responsibility be enforced while such proceedings take place?

I have referred to the indiscriminate appointment of executive supply Officers to the Control-Staff as detrimental to its efficiency; the same system prevails in appointments to the executive departments, and especially to the Army-Service-Corps, and much mischief has been done by the promotion of Non-commissioned Officers to the rank of Commissary. Now, I am and always have been favourable to opening the avenues of advancement to merit wherever it is to be found, and I believe that judicious promotion from the ranks would be a positive benefit to the Army as well as an undoubted justice to individuals; but as a man, because he is a respectable Commissary does not of necessity make an efficient Controller, so another because he is a good Non-commissioned Officer does not of necessity, or even by presumption, make a good Lieutenant or an efficient Commissary. It is not because a man is a well-conducted Serjeant that I would promote him, but because he is too good to remain a Serjeant and qualified for the higher post by superior professional acquirements and education;—this important condition appears to be quite overlooked in appointments to the Supply departments.

It is indispensable for the proper working of the "Army-Service-Corps," that there should be a superior Staff-Officer attached to the head-quarters of the Corps for the purpose of keeping its records, performing duties corresponding with those of the Adjutant-General of the Royal Engineers at the Horse Guards, but he should not interfere in anything affecting local discipline or detail which should devolve entirely upon the General in Command, and upon his Controller as the immediate Commanding Officer. Such an Officer, if of sufficient standing in the Service, would also act as a rallying point for the members of the department generally, who have at present no ostensible chief. The Surveyor-General is too much occupied with his Parliamentary duties to receive his officers (though why the Head of the Control Department should be a political officer is to me quite unaccountable); he has two assistants, but they are concerned with *materiél*, not *personnel*, and so when an old officer who has been knocking about all parts of the world for thirty years or upwards, and has attained a high position, finds himself at Head-quarters, he has to go, hat in hand, to a young Clerk—who is called Private Secretary—and beg the favour of being allowed to apply for a few weeks' leave of absence. The present Private Secretary happens to be an amiable and gentlemanly man, but such an arrangement places him as well as the Departmental Officer in a very false position.

There is only one more point to which I will refer. In Lord Strathnairn's Report, the necessity for some connection between general and regimental "Supply Services" has not been overlooked, but no action whatever has been taken in this direction. It may be remembered that during the Autumn Manœuvres, there were frequent complaints

on the part of bodies of troops, that they had been left without food for longer or shorter periods. Now there was a complete establishment for supply duties under a Controller attached to each division, and there certainly was never a want of food in their magazines or depôts. How, under such circumstances, could a corps remain unprovided? I will tell you, for I took the trouble to enquire particularly into those cases, and I found that in almost every instance the fault lay with the regimental Quartermaster, who, instead of applying to the Commissary of his brigade, waited for the Commissary to find him out and to offer his services. In one or two cases the distance of the depôt from the regimental encampment made communication difficult, for although Quartermasters were provided with horses while employed on this service, they, like some of the Commissaries I have mentioned, were not disposed to trust themselves in the saddle; but the real cause of these failures was the want of a connecting link between regimental and general supply duties. The Quartermaster as he exists, is an obsolete institution, originally the result of the necessity of providing for an old soldier in a manner suited to his position; but under our present organisation, he is a living anachronism. He should be abolished, and in his place we should have an Assistant Commissary attached to each battalion, and charged with regimental supply under the responsibility of the Controller. I am inclined to think that a similar arrangement with regard to regimental Paymasters would prove beneficial, and I am by no means sure that the duties of regimental Paymaster and Quartermaster might not be united in the person of one Commissary.

I am afraid I have trespassed upon your patience and indulgence, and that I have been somewhat severe in my criticisms, but it is precisely because I believe in the soundness of the principle of the "Control" system that I do not hesitate to denounce its defective development. A friend, for whose judgment I entertain the highest respect, wrote to me lately:—"You ask me to name the principal defects of 'Control;' well, keeping in view the Strathnairn Report, I should say that its principal defect is, that it does not exist." Now this is perfectly true; the present Control system is like Ronaldo's horse, which possessed every equine virtue under the sun, but had one fault—it was no longer alive.

The CHAIRMAN: The subject is a very important one, and it is my duty to invite discussion. If any gentleman wishes to make observations on the general subject, or on the details of the lecture, we shall be glad to hear him. It is generally understood that each speaker is allowed ten minutes, and, probably, he will be able to compress his remarks within that space of time.

Assistant-Controller CROOKSHANK: Mr. Chairman, I see there is some slight hesitation on the part of gentlemen present to get up and make remarks upon the lecture which has just been given. I venture, in the first place, to say, that it is a matter of immense pleasure to me, as an Officer of the Department which has formed the subject of the lecture this evening, to see so many Officers present. It is so very much the custom to cry down "Control," so very much the custom to find fault with it, even amongst those who know nothing about it, and perhaps more by them than by those who do know something about it, that the large attendance of Officers here to-night satisfies one that there is within reach of this Institution members who are willing and anxious to hear, and probably to learn something connected with Control, and pick up some crumbs of information—may be

those crumbs will eventually resolve themselves into loaves of suggestion. I must say that we Control Officers labour under a very great difficulty, a difficulty that our lecturer does not labour under. He is on the Retired List; he can write; he can say what he pleases. We are, as you know, tongue-tied, pen-tied. We can neither speak nor write, we have not the opportunities to express ourselves as openly, as plainly, and as audibly, as to the nature of our service, as we would be willing to do. The lecturer to-night has reflected very strongly indeed upon War Office interference. I am sure that both yourself and he, and all here present, will excuse me from touching upon that subject in any way. We are servants of the War Office; and, I take it, very faithful servants of the War Office; that we carry out the instructions of the War Office, not only to the best of our ability, but to the best of our power. Having said that much, I will not allude any further to War Office questions, but rather to the general subject of Control. If I remember right, the Duke of Wellington once said, with a feeling of pride, "If I can do anything in the world, I can feed an army." When he said that, he did not mean he could feed the British soldier with the traditional biscuit and pork that he eats in the field; but when he said he could *feed* an army, he meant that he could *supply* it with everything, from boots upwards. That is now the province of Control. And if we have General Officers who can say in as bold language as the Duke of Wellington's, "I know how to feed an army," depend upon it that, with existing arrangements of Control, that army will be fed, that army will be supplied, there will be no difficulty, no want. I am perfectly convinced—you may say it is a small experience, but it is precisely the same experience that you have all got here, two years, that is about the age of Control—I am quite convinced that, if we take the field, and Control is carried out in its integrity, that the army in the field will not want. Our army ever has been the best fed and the best supplied army in the world, and under this new system I am convinced it will continue to be so, at less cost and less anxiety to the General commanding it. It requires, however, a General who will take any amount of responsibility—a Controller who has got any amount of capability—responsibility on the part of the General and capability on the part of the Controller—and I am quite sure that no British Army in the field will want anything. Referring to the question of our title, I think if there be a mistaken title, it is that of "Control." The lecturer has exhausted that subject pretty well. But I am sure no one here who has ever heard the title used, will differ from me in saying that it is a title that ought to be abolished, and I have great hopes that it will be abolished shortly. What can be more offensive, to use a mild word, than for an Officer to come up to a General commanding a division, and say, "Who is your Controller?" To him it is offensive; to the Controller it is awkward. Again, Controller applies to five hundred things. There is a Controller of the Household, a Controller of the Navy, a Controller of the Stationery Office; and it was only the other day that I, as a member of the Committee of the Army and Navy Club, had to sit in judgment upon a complaint preferred against the Controller of that Club. No doubt it is a title universally disapproved of, and we all hope it will be done away with. Arises the question, what will you call us? I am not in the confidence of those who are discussing the subject. I believe it is under discussion what we are to be called. We are in great hopes that it will be something very distinctive indeed, something that will give us a proper position, which we do not hold now, and unmistakably distinctive from the military element of the Army. Take, for example, the title of Administrative Staff; a General Officer in the field has his Chief of the Staff. He represents the Military Staff only. The Quartermaster-General, the Adjutant-General, the Military Secretary, &c., all look to him as their Chief. Why should there not be two Staffs, an Administrative Staff and a Military Staff, each with its head. It is a suggestion not my own; it has been thrown out before, and much talked of. Some other gentleman in the course of the discussion may find some other and better title. Apologising as a young officer, not in years I am sorry to say, but in the service, for having intruded so long upon your attention, I have to thank you for listening to me so patiently.

The CHAIRMAN: In consequence of what Mr. Crookshank has said very properly, that the officers of the Control Department are tongue-tied, I think I may say that

in a meeting of this sort, no Government would wish, as long as it is fairly done, that any officer, even on full pay, should consider himself tongue-tied.

Colonel ELRINGTON, Rifle Brigade: As Commanding Officer of a battalion for fourteen years, I beg to enter my protest against the suggestion that Quartermasters be abolished, and their places be supplied by Assistant Controllers. I am satisfied the system would not work. Quartermasters are a most valuable body of men, and so far from their places being filled by Assistant Controllers, I am satisfied that they cannot be filled at all. They give a great deal of assistance to the Commanding Officer, and they display a great deal of energy and ability. They carry on their duties remarkably well. They are inadequately paid. Their responsibility has been taken a little off lately, and thrown on the Commanding Officer. Still there they are. The whole control of the working of the battalion rests with them in a great measure, and as a body they carry it out remarkably well and satisfactorily, as I can state from fourteen years' experience.

Captain HOME, R.E.: There is one point I should like to remark upon. With reference to the name Controller, I think if Johnson's Dictionary be referred to, it will show that the word is spelt "Comptroller." Comptroller is a man who deals with accounts and stores; Controller is a man who controls. When the Control Department was first started, as will be seen in the Army List, it was the office of Comptroller that was spoken of. Then, Comptroller was dropped and Controller was introduced. I think the word Controller is one which does not give any idea of control in the sense of comptrolling accounts and stores; whereas Comptroller is a very fair and just term. It is the alteration of "mp" into "n" that has given rise to the objection that has been referred to by one speaker. We have Comptroller of the Queen's Household, and no doubt the Comptroller of the Queen's Household is not a Controller. I think the substitution of one letter for two has led to the difficulty complained of. With regard to the working of the Control Department, I think all orders should come through the chief military Staff Officer. Throughout the whole of the armies in the world, I believe such a thing as any order not coming through the Chief of the Staff is perfectly unknown. I can only refer to *Jomini*, who was a great authority on the subject, and was for many years Chief of the Staff of a large army. He draws attention to the fact that the Chief of "Intendance," the Commanding Officer of Engineers and the Commanding Officer of Artillery, were excessively anxious to deal directly with the General, and not through the agency of the chief Staff Officer. He uses the word "*prétendent*," and the result of such a thing, he says, would be great confusion. He says no General should deal with them, except in the presence of his Chief of the Staff; and all their correspondence should be sent to his Chief of the Staff. I think the principal blot in the Control Department is this fact, that the Controller attempts to go direct to the General. It is a well-established fact that the distinction between the Quartermaster-General and the Adjutant-General's staff is one that has produced a great deal of confusion; and that having one staff would produce great simplicity in our staff arrangements. But here we have a Quartermaster-General's Department, with all the faults of the Quartermaster-General's Department, without any of the advantages it possessed. Another point the lecturer has alluded to, is the division of stores, and I perfectly agree with him. No army in the world, except our Army, has but one Officer placed over the Artillery and Engineer stores, as well as the stores which feed and clothe the Army. That arrangement is perfectly unknown in the world, except in our Army. A very great master of the art of war says "war is not conjectural;" there are certain definite things which must be granted, and which, if once granted, other things will follow from them. I think it must be allowed that we should follow other people in these points. The Artillery and Engineer stores should be decidedly under the Commanding Officers of Artillery and Engineers, and the whole of the department of the Army should be under one staff. Until that is done, I think the Control system, which I highly approve of in many of its details, will never work smoothly. A General Officer should have only one Chief of the Staff, and through him, questions relating to everything should go. He should be the link that unites the civil and military departments together. That is the point where a difficulty arises.

Captain HOZIER, 3rd Dragoon Guards, Acting Assistant-Controller: I am not

prepared to follow the last speaker through the pages of Johnson's Dictionary, or through the French "Intendance." But there is one point in which I think he has made an error with regard to the Control Department; that is, the question of stores. The reason that we differ from all other armies is, that we are a maritime nation. When we make war, we hope that our war will be exterior to our own shores. We must have one single person to whom to consign all stores, or else we shall have the faults of the Crimea over again, when shot and shell and boots, and various other stores, were sent in the same bottoms, but consigned to different persons. The consequence was, ships were sent away loaded with stores, and the greatest confusion was the consequence.

Lieutenant-Colonel FLETCHER, Scots Fusilier Guards: There is one point to which I should like to draw attention, as I do not think it has been quite sufficiently explained in this paper. It refers to the following paragraph: "Non-warlike stores, "indeed everything not coming under the head of Ordnance should remain in "charge of the Control Department, and such division of duty would be easily "carried out since in reality there is no connection between the Ordnance "Branch and the Supply Services, the so-called Controllers of Arsenals per-"forming no general Control duties, and the old Military Store Branch under "its distinct head, continuing intact at the War Office." The question I wish to ask is, supposing in war-time the *munition de guerre* is separated from the *munition de bouche*, and the warlike stores for the army, the shot and shell stand under charge of the artillery, whilst the clothing, food, &c., is left in charge of the Control, how would the transport be managed? Would the transport for the *munition de guerre* be under the Artillery; and would the transport for the *munition de bouche* be under the Control; or would the whole transport be under the charge of one Department? There is another point I was very much struck with, viz., what was said with reference to the education of Control Officers. If high class education is necessary for Staff Officers, and if there are to be continual competitive examinations, I cannot help thinking that the whole Army comprising its Civil as well as its Military Departments, should be subject to them.

In respect to the Autumn Manœuvres, I think an additional cart attached to a regiment would greatly facilitate the supply of food, if it could be given without other inconvenience.

With regard to another subject touched on in the lecture, I would point out that supposing the Regimental Quartermasters were replaced by some other Officer, it would be absolutely essential that whoever might take his place, should be most completely united with the military portion of the regiment, and entirely under control of the Commanding Officer. Otherwise an injurious element would be introduced into the regimental system, similar to what is said to have been introduced into divisional commands, viz.: that of the Control Officer being rather too independent of the General. Not that I think he would be independent of a really firm General, because I cannot fancy such an infraction of discipline occurring where an army, or a division, or a district is properly commanded.

Mr. F. WINGFIELD, late Deputy Assistant-Commissary-General: There is one point to which I wish to call attention. The lecturer has already alluded to it, but has not spoken definitely. It is the question of the advisability of making the appointments in the so-called Civil Departments of the Army, appointments to be held by purely Military Officers; and of thereby abolishing that anomalous character, an Officer of the Civil Departments, whose place would be supplied and whose duties would be discharged by an Officer of the Army, holding the office as a staff appointment. Would not better co-operation be secured if every officer knew that he had to deal with a Military Staff Officer and not with a civilian, holding merely relative rank, whose real position, in a military sense, is ever being called in question?

Captain WEBBER, R.E.: I venture to offer a few remarks. I think where Control, as now organised, has probably broken down and is most likely to break down, is at the point where it meets those whom it has to supply. That link has not been properly considered. We have a splendid organisation, a splendid Military Staff; we have mind, but we have not the power of bringing that mind to matter. That is to say, we can make our warlike stores, we can buy our food, we can hire our transports; but we have not arrived at that point yet, where we bring those things, and

place the food in the mouths of the troops, and place the cartridges in the boxes of the soldiers. It is there, where the chain has broken down; and it is there where we have to make regulations and to produce means which we at present want. I think if this is considered with reference to what has been said to-night, it is in that point alone, that we broke down in the Autumn Manœuvres, and it is in that point that we want experience. A few amongst those have taken part in the discussions on the subject of "the supply of an army," will recollect that we supply our army in India in the most admirable manner. There is no place where the Commissariat is more efficient, and where food and material is more readily brought and placed where it ought to be brought and placed, namely, in front of the soldier. Perhaps, I am speaking to some who have had contrary experience. But that is my experience, and it has always been the experience of those with whom I have talked on the matter. I think the result has been arrived at from this, that the Officers who have been employed to carry out the executive duties of the "Commissariat" have been Officers with whom the soldier and his Officer have sympathy. They have been Officers of the Army who have been selected specially for their "administrative" qualities, who have had great experience with soldiers in the field, who know exactly what is wanted, and how to meet those wants, not merely in their purely administrative capacity, but also in a way which makes the soldier feel that his wants are being met; and seeing that his wants are really being met, he will cease to grumble, he will cease to think that he is not being considered and thought of, and he will feel that the man who is supplying him is anticipating his wants and his feelings, and is doing all he can for him. I think we break down, not because we have not good men and good Controllers, but we break down, in that the soldier and the Officer have constantly on their minds the feeling, that the best that can be, is not being done for them.

The CHAIRMAN: I dare say there are many Officers present who could mention the details of the Indian Commissariat, which has been referred to by the gentleman who spoke last. It might be of great advantage to this Society to hear the details of the system.

Mr. A. S. TOMKINS, Victoria Rifle Volunteers: It appears to me that it is very unimportant whether the Control Department is called the Control Department, or whether it goes under any other name. It also appears to me unimportant whether the Quartermaster is called Quartermaster, or whether he is called Commissary. But it is very important, how the duties are carried out. Having been in a position at the "Autumn Manœuvres," which gave me the opportunity of seeing on certain occasions the working of the Control Department in certain points, it appeared to me, that what might be the cause of a break down, was that the waggons were kept in one place, and the horses were kept in another. In the regiment to which I was attached, so many waggons and so many horses were told off for transport duty. When we marched into camp, the horses were taken out of the waggons, and the drivers and horses had to find their way to the Control camp; which may be in a large division, a long distance from the regiment, and if the regiment arrived on its camping ground after dark, the driver might have great difficulty in finding where the Control camp is: he consequently arrives late, and his meals are distributed irregularly to him. When the army has to move—I believe I am right in saying—a driver is told off with his horses to go to a certain regiment, and it is very possible he may have great difficulty in finding that regiment. I can only say that on several occasions when the battalion to which I was attached, was going out for a field day, we had our ammunition waggon, our water-cart, and our ambulance; perhaps, we had one pair of horses come down, and it was a question with the Colonel which waggon or cart he should take. It appears to me that all that might be avoided if the horses were kept with the waggons. You do not keep your guns in one place and the horses in another for the artillery. With the cavalry, you do not have your men in one place, and your camp for horses elsewhere. Why should it be so with the transport waggons? The man who wants his waggon at a moment's notice ought to have his horses with him ready to put in. In the case of the water-cart, we had one water-cart to four or five battalions; and when it was necessary to fill it, there being no ropes for the men to drag the cart, and often no horses to draw it, we had to wait till the "Control" driver came down with horses and took the water-cart to be

filled. The consequence was that often the men had no water for breakfast, or had it very late. In the case of our battalion, after the first week we had a water-cart and a horse of our own, and then we had an ample supply of water. If we required water we could go and draw it, while the regiments adjoining us were deficient on many occasions, and their dinners were put off simply because they had no means of fetching water.

The CHAIRMAN: If no one else wishes to make any remark, perhaps Mr. Fonblanque will be kind enough, if he has taken down the questions, to answer them; I myself will not refer to any particular opinions, although there are many remarks that might be made; but I think it is due to the lecturer that he should reply to the questions that have been put, rather than that I should take them up.

Mr. DE FONBLANQUE: The first question put was, who should have charge of the transport, in the event of the *munitions de guerre* being separated from the *munitions de bouche*. It was one of the great principles laid down in the Strathnairn Report, in fact, it was the foundation of that Report, that you could not attach responsibility to Supply Departments if you took from them the transport necessary for conveying supplies. The original question for the Committee was (if you will refer to the Blue Book you will find this quite clear), the consideration of transport in reference to supply; and the principle laid down was, that whoever was responsible for supply must have full control of the transport connected therewith. Adopting that principle, I should decidedly say, if you hand over to the Artillery the arms and ammunition, you must give them the transport for their conveyance, just as much as you must give them horses for drawing their guns. I think that principle is now fully established; and if we so far depart from the present Control system as to separate Ordnance stores from other stores, you must *to that extent* also separate the transport.

The CHAIRMAN: Perhaps you will let me make one remark with regard to a point which is very interesting to artillerymen and others. Besides the regular powder, shot, and shell, there are 135 different articles that are stores of artillery common to the rest of the army. I think that is a fact. You may comment upon it as much as you like. Horse-shoes, nails, timber; I could mention a great number. I think the number is 135.

Mr. FONBLANQUE: That are acquired for artillery purposes as well as for the army?

The CHAIRMAN: As well as for the army.

Mr. FONBLANQUE: Then, I should argue, you must make a division in these so-called Artillery Stores. You must draw the line somewhere. I should draw the line strictly at "warlike stores," because food and clothing and camp equipage, and even nails, are things that artillery require in common with the rest of the army. They should not have control of such stores. Let the line be strictly drawn at "warlike stores," stores, the custody and administration of which require a certain scientific knowledge; hand those over to a special staff and give them full transport for this branch of supply. A gentleman spoke in favour of regimental Quartermasters, as against the Commissaries proposed by me; and another speaker, followed very much in the same track, assuming that responsibility would be better kept up under the existing system if a connecting link could be introduced between the general and regimental supply. It is with that very object I would attach a Control Officer to a regiment for supply duties. There *is* the missing link. Under the existing system, a regiment is here and Control is there, and there is no connection between the two. An Officer made a remark about the great value of Quartermasters. But I say the Quartermaster would be very much more valuable if he were connected with the general administration of the army instead of being a purely regimental Officer, utterly cut off from general administration. Then something was said about an additional cart for regimental purposes. The question of regimental transport is a very difficult one. On active service and on certain particular occasions, it is indispensable that regiments should have their transport, but, except on those occasions, for the greater part of the time the horses would be eating their heads off, or carrying Officers' private baggage, or doing something that they ought not to be doing, to the detriment of the general transport of the army.

Colonel FLETCHER: Only on service.

Mr. FONBLANQUE: Certainly, only on service and on special and exceptional occasions. Then, it becomes necessary to provide regimental transport, as was the case during the Autumn Manœuvres—I think the Controller at Aldershot is present, and he will correct me if I am wrong—there was one horse and cart additional for carrying implements, not for food; but I do not think you could do that without greatly increasing the already enormous *impedimenta* of our Army.

Colonel FLETCHER: It was to bring the food from the depôts to the regiments.

Assistant Controller CROOKSHANK: The carts would be only employed for twenty minutes at a time, and I do not think the Chancellor of the Exchequer would approve of that.

The CHAIRMAN: There is a point referred to by one of the speakers with regard to the difficulty that arose from the food-carts and horses of the Military Train being separated. My impression is that the divisions and brigades were so large at Aldershot, so much larger than they are on service, that that might have caused the difficulty. There were thirteen battalions to one division. Thirteen battalions occupy a very large space in line; therefore, I can understand why the horses are sent to one place, in rear of that division, it takes time to get at them; but it is a great object for the Control, whatever name you may give to that Department, that they should have all their horses and men under their own eye, for discipline and for keeping these men and horses in order. This may have been forgotten when complaint is made of separation of the horses from the carts. The carts are brought up to the regiment, and left there, for the men of the battalion to fetch away the food, they have nothing to do with the horses. We may thank Mr. Fonblanque very much for the kindness he has shown in giving us this lecture. It is a question of great detail, and I am sure the lecture and discussion have been very interesting. The more the subject is discussed, the better it will be for the Army.

Evening Meeting.

Monday, March 4th, 1872.

W. STIRLING LACON, Esq., in the Chair.

NAMES OF MEMBERS who joined the Institution between the 20th February and 4th March, 1872.

LIFE.

Pixley, Stewart, Capt., 1st Victoria Rifle Volrs.
Paine, Wm. D., Lieut., 5th Surrey Rifle Volrs.
Notman, H. Wilkes, Capt., Lon. Scottish Rifle Volrs.
Mann, Geo. R., Capt., 1st Middx. Rifle Volrs.
Somervail, Alexander, Capt., 1st. Middx. Rifle Volrs.

ANNUAL.

Vivian, H. H. P., Capt., late 22nd Regt.
Clarke, J. G., Major, late 68th Regt.
Baillie, Wm. H., Capt., late 8th or King's Regt.
Gibson, Edward, Lieut., late S. Gloucester Mil.
Tomlinson, F. P., Lieut., Inns of Court Rifle Volrs.
Leach, E. P., Lieut., Royal Engineers.
Naghten, Arthur R., Major, Hants Art. Mil.
Bevington, Saml. B., Capt., 10th Surrey Rifle Volrs.
Russell, Cecil H., Capt., Inns of Court Rifle Volrs.
Chambers, Arthur W., Capt., 26th Middx. Rifle Volrs.
Chambers, Edward, Lt., Lon. Art. Volrs.
Dixon, Walter C., Lieut., 10th Surrey Rifle Volrs.
Leveson, Edwd. John, Lieut., 5th Kent Art. Volrs.
Hay, H. M., Lieut., Lon. Rifle Brigade Volrs.
Knollys, Henry, Lieut., R.A.
Watts, J. G., Capt., Bombay Staff Corps.
Holland, Stephen T., Ens., 1st Middx. Rifle Volrs.
Farrell, John D. C., Capt., 26th Kent Rifle Volrs.

RIDE-AND-TIE PATROLLING AND SECTION-SKIRMISHING.

By Lieut.-Col. JONES, V.C.

HAVING been invited by the Council of this Institution to fill up a gap in their Programme of Lectures, &c., I embrace the opportunity thus afforded me of endeavouring to secure ventilation for two proposals, which I have termed "Ride-and-Tie Patrolling, and Section-Skirmishing," by way of expressing the subject of this evening's paper as tersely as possible; and, although my notions may be thought crude and impracticable by some persons, I hope for your indulgence while I do my best to lay them before you, and also for some profitable discussion

by any members of the Institution who will kindly take the trouble of refuting or supporting any part of my paper which they may deem worthy of comment.

I need hardly urge, before such an audience as this, the paramount importance of patrolling duties to the safety and success of Armies in the field, more particularly in modern warfare; and it is the well recognised necessity for adopting every expedient calculated to facilitate the performance of those duties which has brought the "ride-and-tie" system to my mind.

"Ride-and-Tie" is, I believe, an old Lancashire expression, denoting the expedient by which two persons get rapidly over the ground with only one horse, by riding and walking alternately, the animal standing or being tied to a rail or gate until the walker arrives at the spot whereon the first rider dismounted for his turn on foot; and, although it may be an extreme way of putting it, this expression so far represents what I wish to bring before you to-night, that it indicates a joint action of small bodies of cavalry and infantry, which has often been employed in war, but hitherto without any previous training in preparation for that intimate association of the two arms in the minor operations of war.

The second part of my subject relates to the fighting of infantry in extended order; and it is my object to show that, by making more use of the "section" than our present skirmishing-drill inculcates, we may, with a given number of men, cover a wider front with more effective fire, and hold the men more in hand for both offensive and defensive action than is possible when the whole are extended in a long line of individual skirmishers.

Without detracting too much from the glory gained by Germany during the late war in France, I believe I may say that the excellence of the Prussian Army in "outpost" and "patrolling duties" was due in no inconsiderable degree to extraordinary deficiency in those particulars on the opposite side, or at any rate that the contrast was thereby thrown more into relief, giving rise to a perhaps exaggerated estimate of the merits of the successful Army; but, after making all due allowance for the deficiencies of her enemy, we must give great credit to the Prussian Army for its uniform success in obtaining good information throughout the campaign.

Perhaps, if we could count upon never meeting a more formidable enemy than the one encountered by the Prussians in 1870, our own light cavalry might be trusted to ride roughshod, as did theirs, over a cowering population, and bring back all required information from a wide range of country; but if we desire to penetrate the secrets of an enemy whose outposts are thoroughly well guarded, whose picquets and patrols are ever alert and ready to capture parties approaching his lines, and whose efforts are supported by inhabitants of the theatre of war, we must find it extremely difficult to obtain the necessary information regarding his designs and movements.

We should not be content, therefore, with rivalling the Prussians in this respect, but should rather try to surpass them by preparing to meet far greater difficulties than they have encountered.

There can surely be no harm in taking a high aim in a matter of such vital importance, and when we clearly recognise the difficulties we are likely to find in our path during the next war, we must be anxious to adopt any plan which may appear well calculated to aid us in overcoming those difficulties.

Patrols formed of infantry, when opposed to an active enemy, would be at the mercy of his cavalry in an open country, and would move so slowly, that they could easily be cut off and captured in an enclosed district; cavalry would do better in open country, but must often be more or less liable to be caught in positions in which it is helpless against a few infantry of the enemy.

Light cavalry are usually employed in small bodies for "patrolling" and "reconnaissance," and I believe there are few Officers of experience in those duties who have not often felt the want of a few good riflemen on foot to dislodge parties of the enemy who, from houses or behind banks and walls, have caused great annoyance to their mounted force.

Such a party of riflemen, judiciously posted behind favourable cover as it advances over the space between our own outposts and those of the enemy, may also very often enable a mounted patrol to advance much further than it would be safe for him to move without the backing up which could thus be afforded; and the check to a pursuing body of the enemy, suddenly encountering the volley firing of these men under cover, would generally ensure the safe retreat of the whole patrol, which might otherwise have been overtaken and destroyed by a superior mounted force.

In order to make the most of such joint action on a small scale between cavalry and infantry,—which joint action is so dependent upon mutual confidence and familiarity with each other's power and modes of action,—I am induced to propose the formation of a "special corps" in which, as a rule, two men shall be assigned to each horse, to work *occasionally* on the principle of "Ride-and-Tie," and always, if possible, to support each other; but the separate action of one man with the horse as cavalry, and of the other as infantry, to be by no means lost sight of in giving this special instruction as to their joint action.

It would be premature to go minutely into the details of organisation before the principle has received some sanction from opinions carrying more weight than my own, and my object to-night is to elicit discussion upon the principle of combining cavalry and infantry in small bodies, in preparation for any occasions on which such united action may be found needful in future wars. I would guard against being supposed to advocate the exclusive use of the "special corps" for the whole duty of the Intelligence Department, and ask your indulgence if, in endeavouring to set forth the advantages of my proposal, I appear to attach undue importance to what can be at best, merely an accessory, additional, aid, under particular circumstances, and not by any means a substitute for the recognised system under which reconnaissance and outpost duties are, and will be, performed by regular infantry and cavalry.

The man intended to be usually mounted should be armed with sword and revolver, and the footman with short rifle and sword bayonet.

The horse could carry a handy spade, saw, and axe, some cartridges for the footman's rifle, and a few discs of gun-cotton, with percussion fuses, besides a very light kit for both men, one cart per squadron bringing up the rest of the men's necessaries.

When the carbine now carried by light cavalry is dispensed with, and a lighter saddle substituted for the one in use at present, I believe that the animal weighted with the above useful articles would nevertheless go into action with less on his back than our light cavalry-horse has now to carry. The greatest possible care should be exercised in the selection and training of these horses, so that they may be trusted to jump ordinary fences, or to stand still while their riders, with or without the assistance of their dismounted comrades, prepare gaps for them to creep over such extraordinary obstacles as may demand a recourse to the tools attached to their saddles.

Whips to hounds, second horsemen, grooms, &c., form the class from which the mounted men should be recruited, while gamekeepers, watchers, shepherds, and detective police would furnish good raw material for the footmen, but the whole force must undergo a careful training so as to develop their individual capabilities.

Education to the extent of reading and writing rapidly, acquaintance with maps and ground shooting, and riding across country, will be required from both classes, although it will be sufficient to demand *excellence* in one of the two latter qualifications from each man of a file, not necessarily from both; nevertheless every man in the corps should be prepared, on an emergency, to shoot fairly with the rifle, or to mount and take care of the horse.

It will, doubtless, occur to many persons that in thus asking for so many qualifications in the same individuals, we may end in getting only smatterers, who would fight badly whether on foot or mounted, and I admit that such would certainly be the case, unless the utmost attention be paid to the selection, promotion, and weeding of this special corps; but so long as the average English gentleman finds time amid a variety of other pursuits, to become a good shot, and to hold his own with hounds, I cannot regard it as impossible to raise a corps of men who can fight "indifferently" on foot or on horse-back, "indifferently" in the strict old sense of that word, which was no doubt present to the mind of Doctor Johnson when he used it to describe the Dragoon of the period.

If love of amusement produces all we require in one class of Englishmen, I cannot see why high and increasing rates of pay, combined with education under the best selected Officers, should not give results with the raw material I propose to draw upon for this special corps.

The best of our police forces and our railway servants have given us good examples of results which may be attained by an increasing scale of pay, in developing special qualities to meet any demand for employments which are somewhat analogous to the one we are now considering; and as the month of annual manœuvres affords the only really good opportunity for training this special corps, I think it will be sufficient to call up the men and horses only on those annual occasions, after giving them some three months' drill on enlistment, and securing

their being always forthcoming by keeping a register and holding a monthly muster.

The men might make their own arrangements about horses (of course under the restrictions for satisfying the demands of the service), and a liberal scale of pay would ensure good discipline if full power be given to the immediate Commanding Officer to fine or dismiss without appeal. Employers of labour would in time learn to make arrangements for sparing their men, and take an interest in helping them to gain a pleasant and profitable annual holiday; but of course the success of the plan would entirely depend upon the selection of Officers to carry it out, and on the offer of terms sufficiently liberal to secure competition for enlistment.

If the extreme importance of patrolling and reconnaisance duties be once thoroughly recognised by the public, there will, I think, be little difficulty about high pay for skilled labour, required only during war, and for one month per annum in peace, to the extent of some 400 men and 200 horses, which would go a long way towards supplying our present need; but as regards the former requisite, I confess to the weakness of this as well as every other scheme which hangs upon the selection of the right man for the right place.

It may be objected that the short training on enlistment, and of a month in each year would not be sufficient to make either cavalry or infantry soldiers. But it should be remembered that this corps would not be required to manœuvre in close order by larger bodies than troops and squadrons, and that the education and intelligence of the selected men, put their training upon an altogether different basis from that upon which we have to build up the training of the ordinary recruit. And if the three months' preliminary drill has to be gone through at the volunteer's own expense, on the bare chance of being selected at its close by a number of the corps, that fact will of itself be a great check upon incompetence, while the direct responsibility to public opinion, under which the selection must be made, will generally ensure a right exercise of that power.

The certainty that each one of the members of the proposed corps will be subjected to military and civilian criticism on each day for which he receives pay during the autumn manœuvres should, I think, be a guarantee to the public that its money is not wasted, and the Officer who should undertake the responsibility of the selection and command, would have the very highest motives for guarding against the admission of any but the most efficient and trustworthy members.

The Corps would, in fact, consist of the very cream of the Volunteers of England, and the payment at the discretion of the Commanding Officer, would establish subordination in the highest degree.

I am a great believer in the efficacy of payment by results, and I also consider that the mechanical repetition of parade movements, is not so good a preparation for the special duties of "patrolling" as the ordinary daily avocations of the classes from which I propose to draw the special corps, and, consequently, I should regard the permanent embodiment of such a corps as rather a disadvantage, independently of the additional expense involved in such a measure.

I have little doubt that, when the requirements and corresponding payments became known, Volunteers equal to the occasion would come forward, even if they found it necessary to pass through a short term of service with regular regiments in order to educate themselves up to the required pitch.

There are many occasions in which men on foot, giving their rifles to their mounted comrades and laying hold of the stirrup-leathers, may double their powers of rapid movement for short distances; and there are other opportunities when a few vehicles may be pressed into the service so as to enable the whole special corps to move over greater distances with the rapidity of light cavalry.

The Germans made many rapid movements of the latter kind in France; and in India we have often used camel and bullock-trains to push rifles along with cavalry.

The Franc-Tireurs appear to have driven the Prussians to adopt this expedient, and I have often wondered that it was not more resorted to on both sides in attacking or defending the long line of columns from the frontier to Paris.

In short, the advantages which have repeatedly been derived from combining light cavalry and riflemen for patrolling, reconnoitring, harrassing, or defending lines of communication, are so manifest, even when the two forces have been put hastily together for the nonce, that all nations will, I think, probably train corps beforehand for such joint action in future wars.

The Special Corps would, of course, be placed at the disposal of the Commander of outposts; and, under ordinary circumstances, it would encamp or bivouac by troops or squadrons with the grand guards of a camp furnishing a small party under a non-commissioned Officer, to each of the picquets to act as orderlies, and to assist the Officers thereof in many ways, by giving information derived from a larger observation of the post than that of the daily-relieved picquet. These parties might be relieved at a different hour from that of the picquet-relief, or might be left for several days according to circumstances, and in either case would, I think, contribute to the security and information of the picquet; but neither they nor the main body of the corps should take part in the regular patrolling except under the orders of the Commanders of picquets, whose responsibility must by no means be weakened by reason of this additional aid to their Commands.

In reference to the Commanders of outposts, I may perhaps be allowed to make a digression from my subject, and propose that the Command of outposts should be divided between two Officers, relieving each other daily, one to superintend the picquets, &c., in the field, and the other to be always at the tent or quarters of the Commander-in-Chief. The duties which must be performed in the saddle in effective superintendence of outposts must always be extremely heavy, and a daily relief might be advocated on that account alone; but I would recommend it especially on the ground that the Officer who was yesterday at the outposts and is to-day in hourly communication with them, would be a valuable assistance to the Commander-in-Chief if always at his elbow.

So much depends upon the proper understanding of reports from the outposts, that I do not consider it enough to secure their being quickly focussed at the point whence the orders are to come, unless some Officer be present on the spot to interpret by direct knowledge of the circumstances under which those reports were made.

The duties of reconnaisance and patrolling of the special corps would be directed by the Commander of outposts, both on the march and in camp, in combination with or independently of the picquets; and I cannot but believe that there would be great advantage to the general interests of the Army which possessed such a corps, always ready for enterprizes beyond its line of outposts; nor do I believe that the regular troops would have any ground to complain of such aid in duties which have become so much heavier than they were formerly.

Professional jealousy of volunteer assistance cannot, however, be suffered to stand in the way, if it can be proved that the work may be done more effectually by a special corps than by all the Army in regular turn of duty.

Passing now to the second division of my subject, viz., "Section-Skirmishing," I may remark that the Infantry Field Exercise Book of 1870 has established a far more practical skirmishing-drill than that laid down by previous editions: but there is one reform, only just hinted at, which I have never seen practically carried out, but which I believe to be most important. I allude to skirmishing by sections or groups, *vide* Section 42, Part III of the Book.

When we recollect that cover, such as walls, ditches, undulations of ground, &c., is to be found on ordinary battle-fields, in patches here and there, rather than in continuous parallel lines, it would appear to be desirable to advance or retreat by small detached bodies in single rank rather than by long thin lines extending over the whole front.

With the increased range of modern arms there need be little danger of the enemy slipping through the intervals between these bodies without his sustaining such an oblique fire from the parties under cover right and left of him, as must leave him in evil case to contend with the supports which would move up to meet him in close order.

I should therefore propose that the ordinary word of command for skirmishing should be—Such and such "companies will skirmish by sections at (say 80 to 200) paces."

Supports and reserves to be formed as at present.

Leaders of sections would then have their men more completely in hand, and could be held responsible for due direction of movement, rapidity of rush from cover to cover, and also for husbanding ammunition, a duty which has ten times the importance it held in former days. They should also be authorised to extend their men at any moment when a line of cover, its total absence, or converging fire, renders such extension desirable.

Such a plan as this would, I think, give a unity of action and elasticity of movement, which is wanting in the line of individual skirmishers.

The Captain of each company would superintend his four sections from the rear, naming one of them to direct which is nearest to the company of direction for the Line, and closing or extending his company on any section according to the requirements of the moment.

I should also propose that the non-commissioned Officers and men be permanently assigned to sections, according to the results of musketry course, in order that there may be a due proportion of marksmen and good judges of distance in each section, and that men and their leaders may gain a mutual confidence and knowledge of each other.

The appearance of a well "sized" company on parade might be wisely sacrificed to gain the substantial advantages of efficient command and more effective fire, which latter must result from the arrangement by which the best judges of distance compare notes as to range, and have their conclusions proved by a few trial shots by marksmen.

A section might in this way determine the exact range within a few seconds after each change of position, and the fire of the whole would thus be infinitely more effective than it would have been if each man had to use his own unaided judgment for the adjustment of his sights.

Of course this system is open to the objection that these sections would present large targets for the enemy's fire; but where cover exists, a heavy fire may be supported without much loss, and when once the section-leader has pointed out the next point of cover, there can be no objection to the section opening out for the rush to it across the open. When a line of cover exists, or the total absence of cover makes it necessary to lie down in the open, the section-leader can, as before observed, extend his men at his discretion.

What I want to insist upon is the handling of skirmishers by leaders of small distinct groups, every man of which is well known to them, instead of by extended lines where men are apt to get out of hand and behind or in front of each other, and where the responsibility of section-leaders is less clearly defined. Only let sections (in single rank, of course,) with intervals, be the *normal* formation of skirmishers, to be departed from at any moment at the discretion and on the responsibility of their leaders, but always to be reverted to on the reasons for extension ceasing to exist.

Another advantage of this plan appears to consist in the facility it presents for forming "section" or "company squares" on the sudden approach of cavalry, and yet another in allowing the free movement of and fire of horse-artillery or field-batteries to aid attack of skirmishers from the rear. The action of artillery in support of skirmishers under the existing system must generally be limited to firing at long range from the flanks, because its guns would otherwise be masked by the extended line in front; but if the line of skirmishers be formed of "detached sections," at intervals of 100 paces or so, as a rule, there will be many favourable opportunities for bringing a couple of guns into safe positions whence they may fire through the intervals upon the decisive points marked out for the attack of skirmishers.

Cavalry also may occasionally be brought forward under cover where the ground is favourable to make sorties, and through the intervals,

with less danger of destroying the order of the skirmishers than when the gaps have to be made specially for the purpose.

"Tactics," as Napoleon said, "change every ten years" for the advantage of that Army which is first prepared to recognise the necessity of adopting the new system; and, although I cannot go the length of saying, as some writers have lately done, that the day of "lines" and "columns" has passed away, I think we shall do well to prepare for changes in the mode of handling each of the three arms. If those writers are not altogether wrong, the system of fighting battles in "extended-order" is in the ascendent, and therefore I hope that the present is a favourable opportunity for considering whether the system of "skirmishing by sections" would not give a consistence and steadiness to the waving weak line which we now present in extended order to the enemy.

It has hitherto been held that skirmishers should cover an Army as a preliminary measure, and be prepared to fall back when the actual collision of more solid formations is about to take place, but the examples of recent battles tend to show, that attacks may in future often be made successful by re-inforcing, instead of relieving and recalling, skirmishers. We may push our skirmishers forward, and watch our opportunity to reinforce them where weak, or where they appear to be making an impression upon the enemy, and in so doing should be lavish in expenditure, not only of the supports and reserves of skirmishers, but of first and second lines, and even of the general reserve, driving our wedges forward, by successive blows from the rear, and using our "close-order"-formations chiefly while out of very effective range of the enemy.

Instead, therefore, of desiring our skirmishers to look back to their main body, we should train them to watch the movements of the enemy, and to keep pressing on in full confidence that any gaps or weak places will be filled up from the rear.

Before extending I would indicate certain points of attack, and charge the companies on the right and left of those points to keep moving to their front, but to fire as much as possible in converging directions upon those points of attack.

The companies marching upon the selected points would fire direct to their front, and profit by the cross fire by pushing forward as opportunities arise, without regard to exactness of line, so as to seize salient positions.

The supports should be held responsible for really carrying out the duties implied by their name, and would be instantly replaced from the reserve, which would in turn draw upon the first line, &c.

Only make the leader of each body responsible for re-inforcing or replacing the one in front of him as it melts away, and leave the actual collision to the energy and discretion of the company-leaders in front.

Making every allowance for the disparity in point of discipline and steadiness, which was so apparent between the French and German Armies during the late war, something like the mode of fighting above described, does not seem unlikely to prove the change of tactics which

may be expected in future wars as the result of recent experience, as shown in the following examples:—

In the attack upon the French right on the Spicheren Heights, at the battle of Forbach, Kameke's entire division became extended as skirmishers, without supports or reserves; and with the aid of a powerful artillery fire from the Galgenburg, held their ground to the end of the battle, contributing most materially to the Prussian success on that day.

Skirmishers and detached company-columns were also exclusively used by Goeben against Faidherbe, and on many other occasions, much after the fashion set in the campaign of 1866, as described in the "Tactical Retrospect."

It is evident, however, that the elasticity and freedom of movement involved in such a mode of fighting must never be suffered to weaken the bonds of discipline, as would be the case if the utmost care be not taken by good Officers to gain and preserve the confidence of their men; for it is sufficiently easy to extend men in an advance, but when a check arises, or retrograde movement becomes necessary, their safety must depend upon the steadiness with which they rally round Company-Officers and Section-leaders, and if these are not in support with their men, the latter should never have been extended. Hence it follows that we should devote the utmost attention to the instruction of our Subaltern and Non-commissioned Officers, if we are to derive the full advantages, and avoid the dangers connected with combat in "extended order."

Our Captains also must be educated in a more independent manner, and taught habits of self-reliance, which are not so incompatible with the most perfect discipline as some persons are apt to imagine; for one who is thoroughly imbued with the true spirit of discipline, and recognises the absolute necessity of obeying and being obeyed (if an Army is not to become simply an armed mob), will submit to his superior, or assume the responsibilities of command with equal cheerfulness; while the unreasoning being who has been cramped by habits of perpetual drudgery on the drill ground, becomes as incapable of independent action and command as the old cavalry troop horse, who snorts and cringes back into the ranks of his squadron when wanted to carry an aide-de-camp or an orderly dragoon. Fortunately, however, the character of the British Officer enables him usually to surmount the obstacles piled up by a long course of "close order" drill whenever an occasion sets him free to exercise his wits in a more independent command, but I am sure there are some of us who have felt the force of the following observations made by poor Rossel in the preface to his "Art de la Guerre." He is referring to the dread of responsibility, and that utter dependence upon their great master, common among the first Napoleon's Generals in the latter part of his career, and which bore fruit in still greater measure among their successors at the head of French Armies in 1870, and he says:—

"Pour oser quelque chose à la guerre il faut être indépendant; com-
"ment accepter une lutte qui toujours a des chances mauvaises s'y l'on
"est accoutumé à s'inspirer de la pensée d'un maître, à s'enorgueillir

" de ses faveurs à s'abimer devant sa colère ? comment s'exposer à une " défaite lorsqu'on n'a pas sa propre conscience pour lui suprême, lorsqu'on " se considère comme puni par une disgrâce comme récompense par un " titre ou un galon ? Le Général qui perd une position, qui laisse " échapper une occasion de vaincre, qui ne profite pas d'un succès, se " retranche derrière la lettre de ses ordres, il a craint de risquer un " revers."

The CHAIRMAN: If any gentleman present is desirous of making any remarks, or to put any questions to the lecturer, we shall be happy to hear him; but what I wish to say applies not only to the present meeting, but to all meetings. The Council are most desirous to organise the discussions, and make them as business-like and to the purpose as possible. They have put up a notice confining each speaker to ten minutes. That, of course, does not apply arbitrarily; but at the end of the ten minutes the Chairman will put himself in the hands of the meeting. If the meeting wishes the gentleman addressing the meeting to continue, well and good; if not, the Chairman will pass on to the next speaker.

Colonel OUVRY, C.B., late 9th Lancers: I think that the proposition which we have just heard from Colonel Jones merits serious consideration—I mean the "ride-and-tie" principle. I think it really very good. We all know that a *reconnaissance en force* is composed of all the branches of the Service, cavalry, infantry, and artillery, and is intended for serious resistance. I do not suppose that Colonel Jones means that the "ride-and-tie" system would be capable of offering any serious resistance; consequently, it would not, in my opinion, be advisable to extend it far beyond the outposts, because it stands to reason that if it were extended to any distance, such as several miles, and were attacked by a superior force of cavalry, the whole must necessarily be overwhelmed. But I think it would be most useful, and far better, when a small force was required, to have the two men and a horse. Of course, there are many minor circumstances which Colonel Jones has touched upon, such as having horses of a peculiar kind, especially broken for the purpose, otherwise they would be liable to fail. But this proposal, although quite new, has been practised among wild eastern tribes. On many occasions they are accustomed to dismount, and, leaving their horses, act on foot. I repeat that I consider the proposal of Colonel Jones is worthy of very serious consideration. As to the second proposition, about "section-skirmishing," I shall leave that to some other gentleman, who is perhaps more conversant with the subject than I am myself.

Sir THOMAS ACLAND, Bart., M.P., Lt.-Col., 1st Devon Rifle Volrs., and Captain Yeomanry Cavalry: I feel that when civilians volunteer to speak on the difficult art of war, soldiers may judge us as we, in our presumption, judge other people when they take farms—we feel that there is only one way to become a farmer, namely, to farm and lose a little money. So soldiers may say to us, "There is only one way of learning soldiering, and that is to fight; lose an arm or a leg, and then you are likely to know something about it." I am glad to be able to shelter myself under the name of so distinguished an Officer as the one who has just sat down, whose works I am sure have penetrated many a civilian's house. I may also shelter myself under the name of a practical Officer, Colonel Bower, who was at the Cape, and who is, what I am not, a very good fox-hunter, with forty or fifty good hunting men attached to his corps at Droxford, in Hampshire. About the same time that his drill-book became known to the public, or a little before, I had the good fortune to make the acquaintance of Colonel Drysdale, of the 9th Lancers, who happened to be quartered in Devonshire at that time. I happened to have the great advantage of having as my Serjeant-Major in the Yeomanry, a regimental Serjeant-Major of the 10th Hussars, and we tried to work out there a system of combining the principles of cavalry and infantry for defensive purposes, because we civilians always thought that we could not be trained for the purpose of attack abroad. Our simple business was to consider how plain men, with good strong arms and legs, with decent horses, with the habit of riding and shooting, could be put in a position where they could best defend their country in case of attack. There were, I think, six corps of mounted Rifles formed in Devon-

shire in 1859. Some have been changed into what are called "Light Horse," and others are not in a very flourishing position, because the system is not showy, and is not taken up by authority. I hope this excellent lecture of Colonel Jones may lead the authorities really to think about the question, whether one of the regular regiments ought not to be tried, to show on what system a mounted man and a rifle ought to be made convertible on the outskirts of an army. It was tried in America, I understand, with several thousands of mounted men under General Stuart and other Officers, and did great execution. I know General MacMurdo attached very great importance to it, and encouraged us and Colonel Bower to go on; and Colonel Bower developed the system by introducing the extension of fours for skirmishing sections.* I should venture to differ from Colonel Jones on one point. I doubt whether it is quite desirable to have only one horse to two men. I think you had better have one horse to one man, and train your men as mounted infantry rather than as dismounted cavalry. That is what General Douglas advised us to do, on grounds which I would venture respectfully to submit to Colonel Jones. You must bear in mind that in asking volunteers, farmers, and country gentlemen to drill as mounted men, you have to deal not only with untrained men, but, what is a much more difficult matter, with untrained horses. You cannot put a farmer's horse into a riding school. A farmer is essentially a horse breeder. He breeds his horse, he rides his horse, he hunts his horse, with a view to sell him as soon as he gets his price. Then he brings on another horse. Those animals are very awkward under fire, and often awkward to lead or link. What struck us in the Yeomanry was this—we were accustomed, on dismounted service, to these horses in charge of centre of threes. In Devonshire lanes it was useless, if you were to move, to have three horses under one man, and we decided that, if the horses were to be mobile at all, there must be too horses, and not three. That led us to what has been since adopted in the English Army, moving by fours, because we were obliged to go by couples with led horses instead of by threes. I may be allowed to mention another difficulty in the way of Colonel Jones's plan. We had, at first, a certain number of mounted men and a certain number of dismounted men united in the same corps. But the mounted man rides his own horse. The dismounted man is tempted to feel a little humiliated, and he wants to have a horse as well as the other man. We were strongly advised by cavalry men not to attempt the union of the two, though General Douglas advised us to go on with it, but we found it necessary after a time, to drill all alike, and let the whole of the dismounted men get on horseback. My only object in making these remarks is to elicit the opinion of men more competent to deal with these things than I am. I should also like to point out another great difficulty in connection with this subject, namely, the mode of arming such a corps. With cavalry, when you come to deal with this question of dismounted duties, it is very difficult to keep out of this scrape, that you have the wrong arm on the man and the wrong arm on the horse. If the man and the horse part company, and the man leaves his gun on his horse, and carries his sword away with him, that is not exactly the state of things you want. The best solution† I have ever seen of it, but which has never been countenanced by authority in this country, is the arm of the *Cent Gardes* in France, who have a very good short rifle, with a rapier nearly three feet long, used only for pointing, and not for cutting, and which may be fixed as a

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* Perhaps I may be allowed to add that Lord Eversley invented a skirmishing drill of a similar kind in the Hampshire Yeomanry. The troop was extended by fours, two men of each section of four dismounting.

† I may add that under Colonel MacMurdo's advice we adopted a sword sling of General Stewart's (U. S.), with a hook which could be detached in a moment from the waist belt and hung by a ring on the saddle. I would also suggest that all administrative or rural battalions should be encouraged to enlist four or eight mounted men per company, so that a battalion of eight companies would have 32 or more guides or covering men, who might organise volunteer transport, and be trained to such duties under a special Officer, as Colonel Jones proposes. I have found my mounted men of the greatest use on field days in covering roads, escorting provisions, taking up camping ground, &c. In every district young farmers and butchers could be found for such work.

sword bayonet. Then, if the man is dismounted and has got his sword he is in a position to join in forming rallying square, if he is overtaken by cavalry. Nothing can be worse than for the dismounted man to be overtaken by cavalry, if he has gone away with his sword and left his gun on the horse. I may venture to claim for our little attempt in Devonshire the high authority of Lord Seaton, who was living in Devonshire for several years before his death. He gave us great encouragement to go on, particularly a little corps near Ivy Bridge, commanded by Mr. Yonge, a connection of Captain Yonge of the 52nd regiment. Captain Yonge invented a belt for the men to carry the rifles on their backs; but I do not think it quite answered. Colonel Bower's Numagua bucket seems the best plan. I cannot but feel personally grateful to Colonel Jones for having brought this subject forward to night, because, although I cannot judge how this system may be used in foreign warfare, it has always appeared to me that in England, where you have so many fox-hunters and good rabbit shots, you want some system to utilise your horse and your gun for defensive purposes. I am afraid we Volunteers cannot give a month's continuous drill, but if you can induce his Royal Highness or the authorities to get a smart cavalry regiment to take up something of this sort, and be trained to it, then you will get the Yeomanry to follow. But you will never get the Yeomanry to condescend to be "dismounted infantry" unless you get a regular regiment to set them the example. I will give a proof of this. Colonel Sir Trevor Wheler, an old Peninsular Officer, trained a corps of Yeomanry in Devonshire called the Royal North Devon Mounted Rifles, in some respects as Colonel Jones would wish. He died, and was succeeded by a cavalry Officer. The formation of Mounted Rifle Volunteers appeared to make the name of Mounted Rifles distasteful, and the regiment has been turned into Hussars, and dressed in imitation of regular Hussars. Unless the Army show us the way, I am afraid the practical solution of the problem before us will never be effected by civilians.

General VAUGHAN, C.B.: I should like to say a few words with regard to Colonel Jones's second proposition, which I think is most specially valuable. Speaking as an infantry Officer of some experience, I think I may fairly say that in every Officer's experience, it must have occurred to him to observe the great difficulty of handling long lines of light infantry in skirmishing order. In the recent campaigns of 1866 and 1870–71, almost all the successes of the Prussians were achieved I believe, by the adoption of a system very nearly analogous to that which Colonel Jones has so ably advocated. Thus in advancing to attack a position, for instance, the front line, which had originally been a thin line of skirmishers, resolved itself, in consequence of being continually reinforced from the rear and the files composing the different subdivisions drawing together, into a number of detached groups of men, each acting with a common object. Supposing that amongst the minor operations of the war, a village or any defended point was to be assailed by the Prussians, their system in the late war, as explained to me by several of their Officers, was very nearly what Colonel Jones has advocated for adoption in the British Army. The Prussian company is divided, if I am not mistaken, into three subdivisions. The usual practice in such cases was, the point of attack having been first indicated, for these subdivisions to move forward, under the command of their respective subalterns, from one point to another, making a rush forward from time to time, as cover offered, until they arrived eventually within a moderate distance of the point to be immediately assailed; then, the movements of the three were combined, and the three subdivisions would rush forward simultaneously to make the final attack, being further supported by a slanting fire from other divisions or groups, pushed forward to suitable positions. I am quite convinced that unless in the British army some training of this kind is adopted as the practice of the infantry, we shall, in the event of being engaged in a European war, find too late, that our present system of infantry drill places us at a great disadvantage. Skirmishers must be trained, and a suitable formation given them to act as principals, not as subordinates, in battle. Holding this view, I think we cannot be too grateful to Colonel Jones, and to other most intelligent and praiseworthy Officers of the British Army, who are now endeavouring to bring to the notice of the authorities, and to force upon them the necessity of altering our drill, and adapting it a little more to the requirements of modern warfare. Further, I believe, as Colonel Jones incidentally mentioned, that the

battles of the two last campaigns have, in all the preliminary portions at any rate, been fought and gained almost entirely, not by the operation of dense columns, or long lines in close order, but by the intelligent and united action of small detached sections, or groups of men. I hope the system will obtain the notice and attention which it deserves from our present Commander-in-Chief; and that he will see fit to institute a system by which troops shall be taught to move in a formation analogous to that which Colonel Jones has so ably put before us, and which is the only suitable formation for the arms, and for the kind of fighting which at the present day has come into vogue. I offer my personal thanks to Colonel Jones for the very pleasant and able way in which he has put this subject before us.

Major COLLEY, 2nd Queen's: The lecture deals with two distinct points. The first is a system of patrolling, combining the two arms for that duty; the other a question of infantry tactics. As regards the first point, I would rather listen to cavalry Officers on the subject, because it is one upon which they could give the best information. The lecturer is an old cavalry Officer, and therefore speaks with authority. Still, I confess my own personal opinion would be in favour of training the cavalry to perform both duties, rather than combining the two arms. I fear the infantry would hamper the cavalry. We all know that the old system of dragoons, men trained to fight, either on horseback or on foot, has been tried and abandoned. At the same time it should be remembered, that improvements in any art consists in accomplishing what was formerly thought an impossibility. Therefore, the mere fact of its not succeeding hitherto is no sufficient reason why it should not succeed in the future. Another reason for urging it is, that we have to consider what system suits our own special conditions best, not what suits foreign armies. It is quite possible the Prussians may not be able in three years to train their cavalry, to be good cavalry soldiers, and to perform the duty of infantry patrols as well. But we have our cavalry soldiers for six years at least, and at present are not even restricted to the six years. The Prussians succeeded in turning out in three years, cavalry soldiers, who performed all cavalry duties extremely well. Therefore, if we retain our men in the ranks for three, or five, or nine years longer than that, we ought to be able to teach them something additional; and I think that something additional should be to act on foot as well. This has been practised a good deal lately at Aldershot and at other places, but I still think not sufficiently. It has been held that first success in war greatly depends upon introduction and application of new tactics; and I think, whatever army first takes the field with a large force of cavalry trained to act as infantry also, will obtain an enormous advantage. The proposal has been made specially with reference to our Volunteers, but I think it applies more to our regular forces, because for the defence of England we shall always be superior in cavalry. Any force that invades us will probably be weak in cavalry and strong in infantry. Our Volunteers should be sufficient to check the enemy's patrols; and our cavalry ought to be superior to any force that is landed, and able to keep us informed of every movement. The other question discussed in the lecture was that of "section-skirmishing." The lecturer has done very great service in bringing that subject forward, for there is little doubt that our tactics require revision precisely in the direction the lecturer has pointed out. Tactics must always be studied under two aspects, the defensive and the offensive. As regards the defensive, I do not think we require much alteration. Our "line formation" and "shelter-trench-drill" are well suited to defensive action, and ought to enable us to hold our own on the defensive against any troops. As regards the offensive, I fear we are not quite so strong, yet it is this which now requires most study. It is manifest that recent improvements in fire-arms are very much in favour of the defensive, this was universally admitted at first; but after a little while persons began to start theories to show that these improvements have been in favour of the offensive, and several works have been written to prove this. But these theories are hardly borne out by facts. If one goes through the statistics of the losses on both sides during the recent war, one finds that in most of the actions in which the Prussians were on the offensive, they lost nearly twice as many men as the French did, that is, excluding prisoners. On the other hand, in those in which the Prussians were on the defensive, their losses were usually less than one-third of the French losses. That is to say, if one takes the loss actually inflicted on the enemy as the standard of comparison, the result is that the losses

on the offensive, as compared with the losses on the defensive, are as 6 or 7 to 1. I think that fairly represents the chances, or I should rather say the difficulties of the offensive, as compared with the defensive. Have we given the former such study as its difficulties require? Some ten years ago I was serving under an Officer who trained us to a system of attack almost identical with that now adopted by the Prussians. We always skirmished. We were trained to attack in skirmishing order, the skirmishers strengthened from the supports, and reserves, if necessary. The point of attack was indicated, and we were trained to charge in loose order, but closing in on the point designated. Each Officer assumed the command of the men immediately in front of him, whether they belonged to his own company or not, and worked with them as a company for the rest of the day. This is almost identical with what is described by the author of the "Tactical Retrospect" as what actually happens in action, and agrees very much with what the Duke of Wurtemburg gives as the result of the most recent Prussian experiences, and if this is what actually occurs in war, it is what men should be trained to in peace. Any one who has watched a line advancing, calculated the number of shots that can be fired at it, before it can come actually into collision, and examined the sort of mark it presents, must have satisfied himself that a line attack cannot succeed against a resolute enemy, armed with breech-loading rifles. The more perfect the formation, the more steady the advance, the better mark it affords to the enemy, and the heavier would be its losses. Ten years ago I came to the conclusion that our line formation, however suited to the defence, was not adapted for offence, and must be abandoned. I have never seen reason to swerve from that opinion, which has been strongly confirmed by recent experiences, and I am happy to think that it is gaining ground now. We must look out for some other system of attack, and here we have the Prussian experiences to guide us. They gained these experiences at the cost of a fearful loss of life. Witness the attack on St. Privat, where they are said to have lost 6,000 men in ten minutes, from adopting too close a formation. It is well for us we have these to guide us, for we cannot afford such losses; had we been drawn into war a few years ago, an adherence to formations of a hundred years back might have cost us an army. The only formation which can succeed in the attack is skirmishing—some system of loose order. Skirmishing means giving each man freedom of individual action. The moment you have individual action, you must subdivide command. As long as 100 men are collected in one company in close order, under the immediate eye and voice of the captain, and only moving by his command, one Officer can command the whole company. But the moment you disperse the men, so that each man must have a certain freedom of action, you must increase the commanders, or you lose all control. You must subdivide the command. The Prussians have aimed at this in their section skirmishing. Their sections do not exactly correspond to ours, as they are independent of the strength of the company, and never exceed 12 men; whereas ours represents a fourth of a company, and might be 20 strong. But the principle is the same; the command is subdivided. They skirmish by sections, that is to say, each man, instead of looking to his captain, looks to the leader of the section, whether Officer or non-commissioned Officer, or only the senior private, and it is the business of the leader of the section to look to the Officer and see that his section conforms to the general movement. It is only by some such system that one man can control a large number, each man at the same time retaining his individual freedom of action. I think, therefore, that the point to be specially studied in our infantry tactics, is *skirmishing* for purposes of attack; and how best to maintain the general command of the captain over his company, by subdividing that command among the subalterns and non-commissioned Officers of the company. One knows under our present system, how the captain is to be seen running from one end of his company to another, thinking it his duty, not to look after the company as a whole, but after each individual man in it. The "section-skirmishing" introduced in the recent drill book, but as yet little put into practice, is a most important step in the right direction, and I think we are greatly indebted to Colonel Jones for calling attention to it at the present time.

The CHAIRMAN: If no other gentleman wishes to ask any question, perhaps Colonel Jones will be kind enough to reply.

Lieutenant-Colonel JONES: I feel very much obliged to the gentlemen who have

kindly commented upon the lecture. Colonel Ouvry, I think, quite agrees with my first proposition. I must be allowed to repeat what I intended to convey in the lecture, that I never intended this special corps for distant operations at all, but simply, as Colonel Ouvry wished, for operations not extending far beyond the outposts. Of course, distant operations would require a larger force. But I consider that there are a great many occasions when the commander of the outposts may require sudden information about a particular point in the neighbourhood of the outpost, quite accessible to a small force. But it must be a mixed force—a force accustomed to each other, and able to go to a certain extent with confidence in one another. I may have made too much of the "ride-and-tie system," but yet I think there is something in it in this way. I maintain that cavalry are of no use firing on horseback. It is an utter absurdity for any man on horse to take aim with a rifle. And if he dismounts he is encumbered with a horse that is not steady. Any cavalry horse is apt to be unsteady when dismounted and the bustle of an action is going on; and the fire of his rider is apt to be disarranged thereby. But if the man can ride up to a point and get off his horse, perfectly confident that his horse will stand still, or, can tie him to a rail, he can have time to take his aim; and the man who has been running up can then take his place, and get on his horse, while the other is going on in front; and so relieve one another in certain ways. It is hardly worth while going into details, because I do not suppose the principle is likely to be recognised. But I have an idea that it might be worked out for a small corps. Now, with regard to what Sir Thomas Acland said, I think he went too far in supposing that I intended the Volunteers or Yeomanry, or mounted Volunteers, to be organised upon this principle at all. I must ask you to recollect that my idea was simply, one special corps formed of 400 picked men out of the whole kingdom. I want a *corps d'élite* for this particular purpose; I do not want to get anything approaching regular troops. I want to get men who will compete to get into this *corps*, and who will really be useful men when they are in it, whom you can trust to find their way across country, and in enclosed countries. We do not really recognise the difficulty of getting information in an enclosed country; your cavalry man can ride about in an open country as far as you like, and get information. But if he is in an enclosed country it is uncommonly difficult to get about without being seen. There are cases in which when two men are going together, one man can creep along on foot, where a mounted man, if he went, would expose himself, and would be seen from a distance. All kinds of cases of that sort, I think, may arise in which it may be useful to have this special corps ready to be called forward. I do not simply propose it as a specific for carrying on all the operations of outpost duty, but as a little aid that may be useful in a duty which has become more and more difficult to perform. I believe we have no conception of the difficulties we shall have in a future war, particularly in an enclosed country like England. We have had no experience of it since the Peninsular war. In the Peninsular war, Wellington had a number of old fox-hunters on his staff, who were most efficient in collecting information for him. But I question whether we are as well prepared at this moment to take it up and to get information in that way. I think the information would be more important, and would require to be more rapidly got in these days than it has ever been. Therefore, I think any little additional aid we can get, however expensive it may be (and it is but a small corps we should require), would be worth while to have, making it an object of competition, so that we should get the very best men. In these days of selection, we are trusting to selection for important purposes. I think here we might select the best men in this country for this corps—Volunteers and other men of the kind. General Vaughan, I hope, concurs with me on the second point, and I think Major Colley does also. Major Colley also seemed to imagine that I put more faith in the "ride-and-tie" system than I do. I quite agree with him in all that he said about the expediency of teaching our cavalry to fight on foot. It is very much talked of on the Continent at present; and most nations are paying more attention to dismounted cavalry work than they have done hitherto. I do not at all see, however, that that is incompatible with my having a special corps for a particular little service, in which they may be very useful. I perfectly agree in his remarks about the expediency of teaching cavalry to work well on foot. I am extremely pleased to find that other infantry Officers agree with me in what I said about the captain

running vaguely about after his men with a sort of idea that he ought to pull each individual man about, and put him into his place, and the major generally galloping about after the captain. The want of subdivsions has always struck me as a misfortune about our "skirmishing drill." I am very much obliged to you for the attention you have paid to me.

The CHAIRMAN: I ask the permission of the meeting to return our best thanks to Colonel Jones for his very interesting paper.

AN OCCASIONAL NOTE ON THE USE OF THE ANEROID-BAROMETER IN SURVEYING.

By Captain R. H. FAWCETT, 33rd Regiment, Garrison Instructor, Curragh Camp.

IN 1868 a notice appeared in the Journal of the Royal United Service Institution to the effect that brief "occasional notes" from Members serving abroad, on subjects of professional interest were admissible, with the approval of the Committee. I propose to avail myself of this permission with special reference to the use of the aneroid barometer in surveying, as I have been so often asked for simple formulæ and the means of applying them to ascertain heights, that I am sure there is much interest taken in the subject by many who have not had opportunities of investigating the powers of the instrument.

The value of the aneroid as a handy and portable instrument for rapidly obtaining relative heights in surveys, has, I think, been underrated. It is of great value, especially in cases of military surveying, where time is frequently priceless.

The points chiefly valuable in an aneroid are its portability, as in the pocket it takes up no more room than a watch, and the observations and calculations can be done so quickly, that a Staff Officer riding from one hill to another, can easily obtain their relative heights.

In a survey, readings may be noted down in a pocket-book, or even on the margin of the sketch, and calculated out on return at leisure.

When there is plenty of time, and the ground is practicable, levelling or contouring would certainly be adopted in preference; but even then the occasional consultation of the aneroid might be an advantageous check to error. But if pressed for time, or contouring be impracticable or extremely difficult, the aneroid gives heights with sufficient accuracy for ordinary military operations, and is far more accurate than the eye; moreover, the reading may be taken in equal or less time than it would require in most cases to make a good judgment of height.

The simple formula given below may be worked out almost directly on the ground, if necessary.

The best example of the value of the aneroid occurs in a survey I lately made of the Nasciar Lines at Malta, and the range, which by a geological fault, divides the island. Here, on account of the rocky and abrupt nature of the formation, and the way in which every available patch of soil has been terraced for cultivation, it would be a most

serious toil at least, to run levels. The aneroid gave me the command of one point over another approximately, with very little trouble. Though it cannot show the height with the accuracy of levelling or contouring, yet its indications may be generally relied on to 10 to 20 feet, according to the care taken, and the number of observations made.

It is of course in abrupt, hilly, and almost mountainous countries, that the aneroid is most useful. For heights of 50 or 60 feet above the plain varying slightly in their relative heights, the reading of the pocket-aneroid might be difficult, and the slightest error important. I have however observations above and below a bridge, the height of which I afterwards measured with a good plumb-line, which show that sufficient accuracy may be obtained with care.

Aneroid observations.		Actual measurement.
1st obs.	2nd obs.	
46 feet.	45 feet.	47 feet.

It almost invariably happens that such small heights can be contoured or levelled quickly, but the case is different with hills of 300 or 400 feet above points in the survey. The contouring of these would take up much time, and the advantage of the aneroid, as far as this reason goes, increases with the height.

The obvious objection to the use of the barometer for ascertaining heights, is the influence of the weather; but this objection seems generally exaggerated. My experience is that, in very stormy, *gusty* weather, the barometer may be influenced so much in the course of a few hours, as to cause uncertainty; yet even in this case, relative heights may be taken, if the points from which the barometric indications are taken, are reached quickly one after the other. A very heavy cloud, that is one on the verge of precipitation into rain, will doubtless have its influence; but, unless a cloud is direct overhead, its influence seems generally gradual, and may be allowed for by returning to some point where the aneroid has been previously consulted, and consulting it again. The mean may be taken, or such allowance made as the duration of time elapsed in passing from one point to the other, warrants. I have done this many and many a time, but found that, as a general rule, the original observations were trustworthy, unless the cloud was dense and directly overhead. It is only in very severe, windy weather, when it is coming on a hurricane, or something like it, that the assistance of the aneroid need be despised; and in this case the prismatic compass itself is almost useless; but, as a rule, very little surveying is done on such days, even in urgent cases; few such days occur in the year at home or abroad.

Most aneroids are compensated for temperature, or should be; the purchaser should particularly make certain of this. Yet, even though it be compensated, it is safer to allow correction for temperature in the case of a survey in hot climates where readings may be taken in the very early morning, and again when the sun has full power.

In reading the indications of the aneroid, the eye is very easily deceived, unless care be taken.

If the aneroid be laid flat on the hand and read, and again held up so that the hand of the instrument shall be parallel to the eyes, there will be found to be a difference.

Again, if it be held *parallel to the eyes* with the higher reading uppermost, the weight of the hand will cause it to read lower than if the position were reversed and the lower reading uppermost. That is, that if the barometer when flat reads 30·10, it may, when held parallel to the eyes and with 28 inches at top, read 30·06, and, when reversed so that 31 inches is uppermost, read 30·04.

The first mode of reading obviously is the most liable to error.

Of the two latter modes it does not matter which is used, provided it is always read the same way. The differences between the readings will be the same. For choice I prefer always to hold it so that the higher number of inches is uppermost. The chief point is to hold it parallel with the eyes; but there is no doubt some fixed rule should obtain with observers.

The mode of using the aneroid for surveying is as follows :—

The reading of the instrument should be taken previous to starting in the place where it is generally kept, or better still from a bench mark (⅄), the exact height of which above the sea, can always be obtained by reference to the Ordnance Survey Department.

On return, the reading should also be carefully noticed at the same place.

If the difference be slight, the mean may be taken as giving the approximate height of the barometer at the time the observations were taken.

For example, if the barometer read—

At starting at 9.30 a.m			29·50
At top of hill	about 11 a.m		28·92
At bottom of hill			29·42
On return at 1 p.m.			29·60

the barometer has risen on account of weather ·10 or $\frac{1}{10}$th of an inch. Hence the height the barometer would have been at the home station at 11 o'clock (when the hill observations were taken) may be estimated as 29·55.

The observations on the hill, if taken soon after one another, will give the relative heights, if this alone be required, without reference to the weather movements of the barometer. If, however, some time has elapsed between the readings, such reference should always be made, and it is obvious that in all cases such proceeding is the more exact and satisfactory.

Some aneroids have a regular scale attached to them, so that the height may be read off. I have never had an opportunity of fairly testing these; they would evidently be exceedingly valuable where the scale could be thoroughly relied on.

In reading a pocket aneroid there is probability of error; in reading the scale there is a second chance of error, and the calculation is so extremely simple that there is no necessity to run the risk of a double error.

A table is given in "Shifts and Expedients of Camp Life," by W. B. Lord, R.A., and T. Baines, F.R.G.S., from which we can see the movements of the instrument at various heights. From this table I make an extract to give a guide to the difference shown per inch of movement at various heights.

Aneroid barometer reading.	Height in feet.	Taken as inches.	Difference in height per inch.
31·00	0	31	—
29·99	900	30	900
29·01	1,800	29	900
28·02	2,750	28	950
27·01	3,750	27	1,000
25·99	4,800	26	1,050
25·01	5,850	25	1,050
23·97	7,000	24	1,150
22·98	8,150	23	1,150
21·99	9,350	22	1,200
20·97	10,650	21	1,300
19·99	11,950	20	1,350

This shows that a fall of an inch in the aneroid has different values at different heights. But it is only for great heights that there is much difference. The barometer at sea level is generally between 27 and 31 inches, unless a West Indian hurricane is afoot; and for military purposes we do not require to ascertain great heights hurriedly. Therefore the following simple formula will generally suffice:—

Admiral Fitzroy appended to his barometer the rule to add 0·1 for every 100 feet of height. In other words, that the barometer would fall 0·1 for every 100 feet. This was probably intended as a general average to suit different positions. Yet it is sufficiently near the mark that Captain James, R.E., has recommended it for surveying, in the Royal Engineer's Papers, giving as an easy rule that a fall of 1 inch represented a height of 1,000 feet very nearly, when the total relief does not exceed that quantity. This rule is extremely simple, and at the very least would enable a near guess to be made at once as to the command of one point over another with a minimum of calculation. But when the barometer generally stands between 30 and 28 inches, the rule given by Negretti and Zambra is—I have always found—very nearly as simple, and more trustworthy. Divide the difference between the aneroid readings at the lower and upper stations by ·0011, the quotient will give the approximate height in feet.

To put this in a form easily remembered, it is that $\frac{d}{\cdot 0011}$ = height in feet, d being the difference between the two stations.

For example—

At bottom of hill aneroid reads ..	30·38
„ top „ „ ..	30·02
d or difference =	·36

$$\frac{\cdot 36}{\cdot 0011} = \frac{3600}{11} = 327 \text{ feet.}$$

This is, to the best of my knowledge, the most useful formula extant.

It differs from Admiral Fitzroy's formula by giving 909 feet to an inch instead of 1000, and is therefore more likely to be true when the barometer reads above 28 inches. There is a formula to be found in Belleville's "Manual of the Aneroid and Mercurial Barometers," which works out very nearly the same for such cases.

As the sum of the readings of the barometer is to their difference, so is 55,000 (or twice the assumed height of the atmosphere in feet) to the elevation required.

$$S : d : : 55{,}000 : x.$$

But for moderate heights this gives little, if any, advantage in accuracy over the one given by Negretti and Zambra. Many other easy formulæ have been given which have not stood the test.

I have by me some 50 cases in which I have worked out the last formula and the one of Negretti and Zambra's, as well as several others. The result I have found to be that the simpler one is sufficiently close for military purposes, and is most rapidly worked. I have tested them against levelling and bench-marks.

Still even for military purposes of surveying, a closer approximation may often be desirable, and Major Robinson, R.E., who made observations in 1849 (*see* "Aide Memoire Papers," vol. ii, p. 418) found "on "investigation that each instrument should have its own register for "indicating heights from certain peculiarities in their construction." This may be done by taking the instrument to a known height and ascertaining the movement. This should be generally done where accuracy is necessary, and not once, but five or six times; and the mean taken of all the observations which may be taken, to give the amount *that* barometer will rise or fall for the height.

No instruments of the kind, even chronometers, can be made exactly accurate; but if the instrument have a constant rate of error, and this be known, we can attain accuracy for practical purposes.

The best way, then, is to select a day and time, or days and times, when the barometer is not likely to be much influenced by the weather, and by carrying the barometer to two points, the difference in height of which can afterwards be accurately ascertained, the rate at which it moves for every 100 feet can be easily calculated.

It may be noteworthy for Officers who may, in the course of duty, have to go up great heights, that I took an aneroid to Abyssinia, graduated to 25 inches, and that, being at heights much over 5,000 feet, the hand came round to 31 and 30 inches or so for the second time. I thought the aneroid must be thrown out by this, and discontinued observations. On return home, I left it for some time with the makers, but was assured that it had been working correctly, and moreover was told that the difference between 25 and 31 was purposely exactly an inch. I might therefore have gone on with the observations, merely reading 31 as 24, 30 as 23, and so on.

On the other hand, Captain Tupman, R.M.A., informs me that an aneroid in his possession was thrown out of gear, though not seriously, by being taken up a height beyond what it was graduated for.

It may be as well to ascertain this point from the optician at the time of purchase, as well as what the difference given by the instrument for each 100 feet at 30 inches is; but, above all, see that it is compensated for temperature, as most are now.

A large aneroid is more accurate and more easily read than a small one, but it is not so portable. A pocket aneroid can be easily slipped into the coat pocket, and I think this preferable to carrying it in the waistcoat pocket; for the object is to keep it at about the same temperature. In ordinary work, the waistcoat pocket would be the best place, as it is for a watch; but when a man tramps up a steep and high hill he becomes much hotter than he was at the foot; this might affect the aneroid in his waistcoat pocket, but not that in his coat pocket. The small aneroid might enable one to take useful observations in an enemy's country without suspicion.

For the benefit of Officers serving abroad, where books may be inaccessible, I append the formulæ given in "Practical Meteorology," by Dr. Drew, and extracts from his table sufficient to enable them to be worked out. Any one, however, taking up the subject thoroughly, should have that work for reference.

Speaking of the aneroid, Dr. Drew says, "As no correction need be "applied for temperature as regards instrumental variation, a simpler "formula may be adopted than for a barometrical barometer; perhaps "the best is one by Poisson, from which Professor Patton (in the "Journal of the Geographical Society, vol. xxi) has derived the follow-"ing rule:"—

Multiply the number in the following table opposite to the mean of the temperatures of the air at the two places (in degrees of Fahrenheit) by the difference of their barometrical heights, and divide by their sum.

$$x = \frac{d\,\mathrm{T}}{\mathrm{S}}$$ where d = difference of barometer readings.

T = number opposite mean temperature.
S = sum of barometer readings.
x = height in feet.

Condensed Table.

At 32° = 52416.
40° = 53348.
50° = 54512.
60° = 55677.
70° = 56842.
80° = 58007.
90° = 59172.

If the number 116 be added or deducted for every degree of the temperature above or below the nearest temperature for which a number is given, then a close approximation is reached.

For example, let temperature at the top of the hill be 48°, and at the foot 56°, then the mean temperature is 52°.

T for 50°	= 54512
Add 116 × 2	= 232
T for 52°	54744

Again, if the mean temperature be 57°.

T for 60°	= 55677
Deduct 116 × 3	= 348
T for 57°	= 55329

The formula and table may be written on a small piece of paper, and gummed on the back of the aneroid.

Dr. Drew gives also other formulæ, but this is the simplest; and, as before mentioned, it is only in the case of a considerable height and some range of temperature, that it is necessary to take the latter into consideration at all.

In conclusion, the aneroid is so peculiarly handy, portable, and adapted for obtaining useful results in military surveys in war, that I consider it would be a great advantage if, in the ordnance survey, some of these instruments might be thoroughly tested with regular levellings, so as to prove their comparative accuracy. From this we might hope to obtain more exact formulæ than we have at present, especially with regard to heights between 100 and 800 or 900 feet.

I have written this in great part for the inexperienced, for I hope to see the aneroid some day in general use with Officers.

Those who wish to go thoroughly into the subject, may get information from—

Practical Meteorology, by Dr. Drew, p. 219 *et seq.*

Aide Memoire, vol. 2, p. 418.

Royal Engineers' Papers, vol. 7, p. 28 *et seq.*; vol. 8, p. 176 *et seq.*

Symon's Meteorological Magazine, June—August, 1866; October, 1867; November and December, 1870; February, 1871.

Shifts and Expedients of Camp Life, &c., by W. B. Lord, R.A., and T. Baines, F.G.S., p. 742 *et seq.*

APPENDIX.

The following is a specimen of the working of an afternoon ride over a survey, to settle some points doubtful and to take in one or two new ones of small importance.

The ride was about 20 miles, but, on account of the difficulties of ground and detours requisite, the points could not be reached so quickly one after another as would be generally possible.

Time, P.M.	Position.	Barometer reading.	Height in feet above sea level by this observation.	By previous observation.	
3.0	At home	29·72	—	—	—
3.15	Pieta (5 ft. above sea level)	29·88	—	—	—
3.30	Bench mark 229 on road..	29·84	46	—	By Ordnance survey afterwards ascertained, 50·258.
3.50	Dome of Musta.....	29·64	232	230	—
4.0	St. Speranza	29·68	195	—	By previous observation, a difference of 50 feet in relative height between S. Speranza and Andrea.
4.15	St. Andrea.....	29·625	248	—	
4.40	Top of Gebel Mir Hanno..	29·58	295	—	—
5.0	Valley at St. Caterina	29·825	73	70	—
5.15	Via Selina and Mellcha ..	29·75	141	137	—
5.45	St. Giovanni	29·80	102	—	—
5.55	Chapel at fork of roads ..	29·75	160	147	—
6.0	Bend of road to P. Camp.	29·79	114	120	—
6.10	Madalena Tower, 5 ft. above sea	29·915	—	—	—
7.0	Pieta, 5 ft. above sea	29·92	—	—	—
7.15	At home (on return)	29·75	—	—	—

Barometer at home 3.0 = 29·72.
Ditto ditto 7.0 = 29·75 between 3 and 7 (4 hours), hence presumable rise through weather = ·03.
Barometer at Pieta (5 ft. above sea) at 3.15 p.m. = 29·880.
Ditto Madalena at 6.10 „ = 29·915.
Ditto Pieta at 7.0 „ = 29·92.
Presumable rise through weather in 4 hours = ·04.

As from the general working of the barometer through the previous part of the day and the condition of the day, there appears no reason to expect any sudden "jump" in the barometer, we may allow for weather a rise of ·01 every hour.

That is, that at 3 p.m. the bar. at 5 ft. above sea would read 29·88
„ 4 p.m. „ „ „ 29·89
„ 5 p.m. „ „ „ 29·90
„ 6 p.m. „ „ „ 29·91
„ 7 p.m. „ „ „ 29·92

Taking these conditions, we proceed to compare them with the readings at different heights at and about the times:—
Bench mark (229) on road at 3.30 p.m. reading 29·84
5 ft. above sea level 3·30 p.m. 29·885.

1st Formula:

Lower station 29·885
Upper „ 29·840

d or difference = ·045

S or sum = 59·725

$$\frac{d}{\cdot 0011} = \frac{450}{11} = 40{\cdot}9$$

Add 5 feet 5

Height above sea level 45·9.

2nd Formula: S : *d* : : 55000 : *x*

59·725 : ·045 : : 55000 : *x*

$$\frac{55000 \times \cdot 045}{59{\cdot}725} = 41 \text{ feet above Pieta point.}$$

Add 5 feet = 46 feet above sea level.

Height taken as 46 feet.
And so on with each reading.

"THE AUSTRIAN CONFIDENTIAL REPORT AND NEW METHOD OF PROMOTION."

By Lieut. CHARLES E. H. VINCENT, 23rd Royal Welsh Fusiliers.

THE subjoined description of the detailed confidential report, which is furnished annually to head-quarters on every Officer in the principal Continental armies, may be found interesting. It is needless for me to remark how invaluable it has proved in the Prussian service. By its agency alone, the right man was always appointed to the right place. The tactical genius found himself brought before the enemy, whilst the more sedentary and inactive talents found ample employment in the difficult task of administrating the civil government of conquered provinces, towns, and villages.

In time of peace a post falls vacant. May be, it requires private means, social qualification, a somewhat peculiar knowledge or temperament. Reference is made to the ledger at head-quarters, and the choice becomes limited to two or three from whom it is not difficult to select. In war, Officers commanding divisions, detached posts, &c., are furnished with a summary of the principal qualifications of each Officer under their command. A "parlementaire," somebody to examine deserters, to attend on a prisoner of rank, is wanted. The "summary" instantly facilitates the appointment. I will take the Austrian Report as the specimen, entering as it does into the minutest details.

It is written on a printed form at half margin. The questions or points on which information is to be furnished are printed on the left. The information is to be written explicitly, yet concisely, on the right.

Page 1 shows—Corps, name, rank, employment, date of birth, religion, education, place; mode and extent of ditto before

entering army. Personal relations before entering service (in any other profession or army). Date and method of entering army. Courses afterwards passed through. Private relations (married, single, or a widower, children, independent means). Medals or decorations.

Page 2—Promoted, transferred, passed over, &c. Length of service absolutely with corps.

Page 3—How been employed to be given year by year (if the Officer has been employed in various ways to be shown thus) :—1868, January to June, Acting Adjutant; 1868, June to December, Comptroller duty; 1869, January to March, Aide-de-Camp; 1869, March to October, Musketry Instructor.

Page 4—Campaigns, wounds, services in the field.

Page 5—Special services. Special and peculiar abilities, painting, gymnastics, swimming, drawing.

Page 6—Year to which Report refers. Present employment, knowledge of languages (whether slightly or thoroughly). Capabilities in matters connected with military duty (riding, judgment in horseflesh, training of recruits, &c.). Capabilities in matters unconnected with military duty. Zeal, success, ambition, thirst for knowledge. Conduct and character before the enemy, on service in peace, in private life. State of health, fitness for a campaign. Special remarks. Claim for promotion. Remarks by Inspecting General.

As the General's report checks that of the Commanding Officers, it is difficult for the latter to show pique or favoritism I will but add one word on the new law for promotion in the Austrian Service (March 14, 1871).

Promotion goes by seniority or non-seniority. Those who elect for the more rapid advancement of the latter method, which is open to all, have to pass a very severe practical and theoretical examination. They are then promoted in numerical order on the list of successful candidates. Every sixth step below field rank, and every fourth above it, is given to a non-seniority candidate. Promotion goes right through the Army, arm by arm. In all cases, Captains have to submit to a very severe practical and theoretical test before they are promoted; to prepare for which, it is optional with them to study for eleven months at a special school, and all promotion depends on "thorough fitness." The Staff is organised much on the model of our own, but "mathematics" form no part of the entrance examination to the Staff College, or of the course of instruction there, while civil administration, the exact topography and military power of every European State are the objects of unceasing study.

The Journal
OF THE
Royal United Service Institution.

VOL. XVI. 1872. No. LXVII.

LECTURE.

Friday, March 22nd.

LIEUTENANT-GENERAL THE HON. SIR JAMES LINDSAY, K.C.M.G., Inspector-General of Reserve Forces, and Vice-Chairman of the Council, in the Chair.

"THE STRATEGY OF INVASION, AS EXEMPLIFIED IN THE AMERICAN AND AUSTRO-PRUSSIAN WARS, AND IN THE WAR OF METZ; WITH REMARKS ON CENTRES OF DEFENCE AND THE TRAINING OF NATIONAL FORCES."

By Colonel Sir R. A. SHAFTO ADAIR, Bart., F.R.S., A.D.C. to the Queen.

The CHAIRMAN: Sir Shafto Adair, requires no introduction to the members of this Institution. The Institution has so often benefited by the lectures which he has given, as well as by the models which he has presented to the Museum, that I pay him the compliment of saying that no introduction from me is necessary. He has distinguished himself as a writer, as a modeller, and as a lecturer, and the army has benefited by the service which he has rendered to this Institution. I have, therefore, great pleasure in asking Sir Shafto Adair to come forward and give us his lecture.

Sir SHAFTO ADAIR: It is my first and pleasant duty to express the thanks that I owe to the Council for their consideration in having allowed me to postpone the lecture which I am permitted to give this day. It is a lecture on a subject, as I venture to think, of exceeding importance; one that has assumed a prominence as the social question of our day since I last had the honour of addressing you in this theatre.

The question which I propose to treat, is the "strategy of invasion," and in some degree to endeavour to gauge what may be called the processes of national thought that lead to invasion, and the means of resisting and of consolidating the national forces against it. For though the nation is unfortunate indeed, that is always preparing for war, that nation must be still more miserable that is not prepared for war when it comes. I speak of the "strategy of invasion," and here,

though a definition is proverbially dangerous, I would endeavour to express the force that the word strategy conveys to my mind. There has been, I venture to think, without presuming to say that I shall accomplish the solution, a great confusion made between strategy and tactics. To place the matter before you, I would say that by strategy I understand that preparation for war which makes the success of given movements probable; and tactics to be that preparation which makes them possible. We have seen instances in which high strategic talent may not be connected with the means of carrying strategic movements into effect for want of tactical development in the troops that are employed. On the other hand, a highly elaborated tactical system may not give occasion, or not find employment, for great strategic skill. It appears to me that such is the better way of investigating this question, inasmuch as the idea of invasion, a novel one to a great extent in the forms in which it has been lately made evident in Europe and in America, should be investigated and sounded to its depths. Invasion means a war of a decisive and severe character. Invasion means a war not merely to occupy military posts, or islands, or to divert the course of commerce; but, as we have seen it exemplified in later years, it means that effort of armed force which shall substitute entirely one system of government and ideas for another; or, shall leave the vanquished party so helpless that for years to come it may probably be unable to emerge from the state of humiliation and defeat in which it has been left at the close of the contest.

In reviewing this question, the chief and most prominent agent in the late European wars of invasion is that mass of armed force which is now consolidated under the name of the German Empire, which has been developed on the nucleus of the Prussian monarchy. It may appear strange, but it is clearly to be proved and traced, that the idea of the unification of the German Empire lay at the bottom of all the wars that we have seen on that account of later years. To reduce the question to a simple expression of formula—from Jena to Sadowa, from Sadowa to Sedan was one unbroken continuous line of action. In 1813 the Prussians with a noble courage, recovering from their utter humiliation and defeat, joined eastern Europe in an attack on the French Empire. From 1813 to 1815—16—17, their period of supremacy was unchecked in the occupation of France. Then, I make no doubt that the pressure of French conquest which had held down Germany, generated a craving for German unification, of which Prussian policy became the exponent in the institution of the Zollverein, and has been finally the armed apostle at Sedan. For it will be remarked, that in 1818, the Prussians commenced that course of consolidation by their custom-houses, which they have now welded together by their arms. And in this course of unification necessarily, such a supremacy would probably be challenged, and such has proved to be the case, by the hereditary opponent of the Prussian Monarchy, the Emperor of Austria. Thus, then, the campaign of which the first period terminated at Königgratz, and closed at Blumenau, was forced, as it were, upon these two great empires by that fixed determination of the German-speaking

race to be one people, which had been shown to a slight extent on the dismemberment of Denmark, and received its full development after the defeat of the Austrian Armies.

So, then, we have to consider whether this idea be not of so intense a description as to give a new feature to war; if, in fact, it be not true that the armies of even the eighteenth century are of power inadequate for the demands that are now made upon military resources, in order to gratify desires which are wide as the national impulses. From this point of view it will be seen how wise and sagacious, as well as effective, the Prussian arrangements and preparations have been.

Prepared for war at a moment's notice, with enemies in front, in flank, and in rear, as soon as the hour sounded had struck, Prussia hesitated not for one moment to strike quickly and strongly. And there is a simplicity with respect to the Prussian movements which will dispense with my directing your attention on successive points, to show how the tide of battle ebbed and flowed; for when the quadruple arrangements of the Prussian armies are once detailed, the army of the Main on the proper right of the army of the Elbe, and of the first and second army, and, as will be familiar to you all, the objective point of Vienna in the distance, the whole plan of the campaign of Sadowa lies before you.

I would here request your indulgence for a moment to say, that I do not propose to enter upon the movements that have decided battles. Other writers and speakers have dilated upon them; indeed, the time would fail me if I were to attempt to pause upon many a noble movement, upon many a feat of arms. I propose simply to indicate the detailed movements of the armies, and to enquire how far these are consistent with the principle which I have to lay down, that every nation must have its centres of defence, and that that nation is most fortunate in its preparations for defence which is so constituted, geographically, that the lines of hostile approach must be known. On this I shall have to speak more at large when I come to the defence of our own shores.

Thus, then, with sudden surprise, the Prussians broke up from Berlin, leaving to the army of the right-flank the care of the outlying Hanoverians and Bavarians, and pressed forward with a boldness which might almost be considered rashness, if they had not been perfectly confident of their own resources and power of reparation in losses or defeat. They could not have known of the resistance they were likely to encounter, or how far it would fail the Austrians, like the broken reed, when the hour of struggle came, as it did in too many instances. This they could not have known, but confident in their own strength they pressed forward, and after subjecting themselves to the chance of considerable reverses, with the objective point of Vienna before them, the great fight at Königgratz or Sadowa was fought, which is the term of the ascendancy of the Prussians in the Germanic empire. I propose before I leave this subject to remark generally upon the military advantages which the Prussian system presents. But at this juncture one magnificent strategical movement or inspiration seems to have waited on Prince Frederick Charles, the Commander of the first corps. He guessed, though he did not know, where the Austrian